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People & the Planet

Volume 8 Number 2

SUSTAINABLE ENERGY

Front cover: Wind energy park, North Germany
Credit: Martin Bond/Science Photo Library
Left: Making dung cakes for fuel, West Bengal
Credit: Nancy Durrell McKenna/Panos Pictures

People & the Planet

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Silent revolution

In a talk, in London, last year Jim Dawson, President of Shell International Renewables, presented some slides showing how that oil giant views the energy future. To the amazement of many in the audience, he predicted that under conditions of two per cent sustained annual economic growth, more than half the world's hugely increased energy needs by 2050 would be supplied by renewable energy sources. Within 50 years, in other words, wind, non-traditional biomass, solar, geothermal and other 'surprise' renewable energy sources will, Shell believes, be more important than all the fossil fuels put together. Even under conditions of dematerialised production – allowing for much more efficient use of energy – renewables will, Shell predicts, become more important than coal and oil put together. That is, indeed, a revolutionary transition and one that has crept up on us quite silently.

This issue of *People & the Planet* explores this momentous move from the fossil fuel age, with its monoculture of centralised power production, to a new world of efficient, local, non-polluting energy sources, with the potential to literally 'empower' everyone, in villages and mega-cities alike. Our contributors build up a picture of a world in which city roofscapes incorporate "thin film" solar cells, buildings meet their own energy needs and feed surpluses into the grid, cars and auto-cycles become home energy appliances, topped up at night with hydrogen and electricity, vegetable wastes of every sort are efficiently transformed into heat and power, while wind farms quietly feed non-polluting electricity into local and national power systems.

But as world population doubles, and consumption soars, how this transition is handled, will be all important. As Christopher Flavin and Seth Dunn point out, the speed of change will depend, in part, on whether fossil fuel prices remain low and on the opposition of the coal and oil industry to curbs on greenhouse gases. It will also depend on how quickly the perception dawns that energy efficiency is an advantage to business and not a burden. As Amory Lovins has said, "The earth's climate can be protected *not at a cost but a profit...because saving fuel costs less than buying fuel*." The speedy spread of renewables would also be a special benefit to the one-third of humanity with no access to the electric grid, as Lou Werner's report from Bangladesh graphically describes. Fortunately, it seems that some developing countries, at least, are well placed to leapfrog into the new energy century.

John Rowley

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newsfile

SIX BILLION DAY

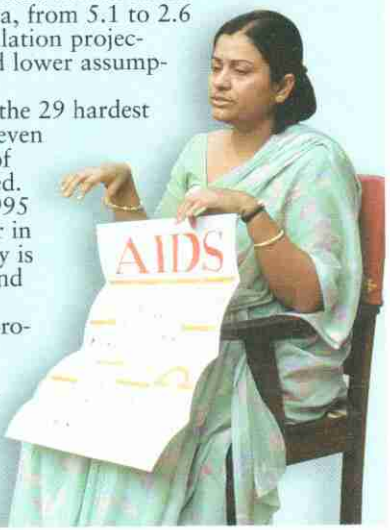
UNFPA has announced that the Day of Six Billion will now be marked on 12 October 1999 instead of 16 June, because revised UN population estimates show that population growth has slowed, due to lower fertility and higher mortality caused by AIDS. World population in 2050 is now expected to be in the range of 7.3 to 10.7 billion, with a median figure of 8.9 – 500 million fewer than the 1996 Revision suggested.

The 1998 Revision of the official UN world population estimates and projections shows that global population is currently growing at 1.33 per cent per year, an annual net addition of some 78 million people. The global average fertility level now stands at 2.7 births per woman, down from 2.9 two years earlier. In the last 25 years, the number of children per couple has fallen from 6.6 to 5.1 in Africa, from 5.1 to 2.6 in Asia, and from 5.0 to 2.7 in Latin America and the Caribbean. The future population projections reflect faster than expected fertility declines in some developing countries and lower assumptions about future family size in most industrialised countries.

The 1998 Revision demonstrates a devastating mortality toll from HIV/AIDS. In the 29 hardest hit African countries, the average life expectancy at birth is estimated at 47 years, seven years less than it would have been in the absence of AIDS. The highest prevalence of HIV in the world is currently in Botswana, where one of every four adults is infected. Life expectancy at birth in Botswana is anticipated to fall from 61 years in 1990-1995 to 41 years by 2000-2005, and the country's population may be 23 per cent smaller in 2025 than it would have been in the absence of AIDS. Nevertheless, because fertility is high, the population of Botswana is still expected to nearly double between 1995 and 2050.

The figures in the 1998 Revision shed new light on the global population ageing processes. For the first time, the numbers of elderly are estimated and projected for all countries of the world. In 1998, 66 million persons in the world were aged 80 or over, or about one of every 100 persons. This number is expected to increase almost six-fold by 2050 to reach 370 million persons. In addition, in 1998, around 135,000 persons in the world are estimated to be aged 100 or over. The number of centenarians is projected to increase sixteen-fold by 2050 to reach 2.2 million persons.

Source: *World Population Prospects, the 1998 Revision*, UN Population Division, New York, 1999.



Peter Barker/Panos Pictures

EDUCATION CRISIS

Nearly a billion people, two-thirds of them women, will enter the 21st century unable to read a book or sign their names. The total includes more than 130 million school-age children, 73 million of them girls, according to UNICEF's *The State of the World's Children 1999*.

"The consequences of illiteracy are profound – and even potentially life-threatening," said Carol Bellamy, UNICEF's Executive Director. The report shows there is a direct correlation between years of schooling and child mortality rates – and that education has a greater impact on health indicators than health, nutrition, water and sanitation interventions.

A 10 percentage point increase in girls' primary enrolment can be expected to decrease infant mortality in their children by 4.1 deaths per 1,000, and a similar rise in girls' secondary education by a further 5.6 deaths per 1,000. This means that an extra year of schooling for 1,000 girls would ultimately prevent roughly 60 infant deaths. Each extra year of school for girls can also translate into a reduction in fertility rates, as well as a decrease in maternal deaths, says the report.

The report says that children who grow up without basic education not only find it harder to sustain themselves and their families, but also to make their way in society in a spirit of tolerance, understanding and equality. Education helps people learn how to achieve fundamental human rights such as health, nutrition and safe motherhood while improving the quality of life.

The report stresses the vital importance not only of access to basic information but also of the quality of that education. For example, there are 150 million children in developing countries who started school but never reached grade 5. They leave school without the literacy, numeracy and life skills that are the foundation for learning throughout life.

To achieve education for all children, as agreed by the world's nations when they adopted the Convention on the Rights of the Child in 1990, the world would need to spend an additional $7 billion per year over the next 10 years. This is less than is spent annually on cosmetics in the United States or on ice cream in Europe, and is less than a tenth of the world's annual spending on armaments.

UNICEF/96-1142/Zaman

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ORGANICS BOOM

Consumer demand for organically produced food is on the rise and provides new market opportunities for farmers and businesses around the world, the UN Food & Agriculture Organization (FAO) reports. "Under the right circumstances, the market returns from organic agriculture can potentially contribute to local food security by increasing family incomes," it says.

Though only a small percentage of farmers are expected to become organic producers, in several developed countries organic agriculture already represents a significant portion of the food system: 10 per cent in Austria and 7.8 per cent in Switzerland. Other countries such as the United States, France, Japan and Singapore are experiencing growth rates that exceed 20 per cent annually.

Some developing countries, such as Egypt, have small domestic organic markets and have begun to seize the lucrative export opportunities presented by organic agriculture.

What makes organic agriculture unique is that almost all synthetic inputs are prohibited, and 'soil building' crop rotations are mandated. "Properly managed organic farming reduces or eliminates water pollution and helps conserve water and soil on the farm, although improper use of manure can seriously pollute water," FAO said.

Reduction in the use of toxic pesti-

cides, which the World Health Organisation estimates poison 3 million people each year, should lead to improved health of farm families. Organic farming could enhance sustainability and agro-biodiversity, but it should not be seen as an exclusive method for sustainable land use, FAO said.

This FAO report was prepared for the Committee on Agriculture which met in Rome in January. For more information see their website:www.fao.org/unfao/bodies/COAG/COAG15/default.htm

HELPING MOTHERS

Twelve years after the global Safer Motherhood Initiative was launched in Nairobi, Kenya, in 1987, the partnership of agencies involved has issued a new Action Agenda, setting out Priorities for the Next Decade.

This is badly needed since the annual toll of deaths from causes related to pregnancy (the biggest threat to women's lives in the developing world) has remained steady at around 600,000 every year. Put another way, every minute 380 women become pregnant, 110 face a pregnancy-related complication, 40 have an unsafe abortion and one dies.

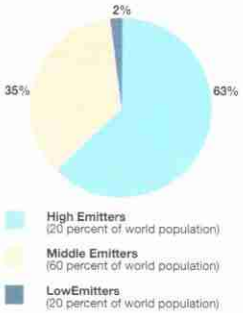
The 95-page publication highlights ten key interventions which can help reduce the toll of death and disablement which still afflicts so many women in pregnancy. These include working with traditional birth attendants, ensuring skilled attendance during childbirth, strategies for mobilising transport when emergencies arise, the potential of Vitamin A supplements and the need to address unsafe abortion which kills almost 80,000 women each year.

The Safe Motherhood Initiative sponsors include UNICEF, UNFPA, the World Bank, WHO, IPPF, and the Population Council. *The Safe Motherhood Action Agenda* and other materials are available from Family Care International, New York, which acts as the Secretariat for the Initiative.
Tel: 212-941-5300, Fax: 212-941-5563,
Email: smi10@familycareintl.org
Website: www.safemotherhood.org

CARBON CRUNCH

A new report issued by Population Action International brings together for the first time, year-by-year data on national populations and carbon dioxide emissions from fossil fuels to produce profiles of per capita CO_2 emissions for 179 countries over a 45-year period.

The study includes a graphical ranking of countries greater than one million by their 1995 per capita emissions, as well as information and charts on related population and emission trends.



The profiles show that industrialised countries, with relatively slow growing populations, have the largest per capita emissions while countries with rapidly growing populations, by contrast, have very low per capita greenhouse gas emissions though growth in per capita emissions tends to be most rapid in these countries. Currently, the highest emitting fifth of the world's population contributes 63 per cent of documented CO_2 emissions while the lowest emitting fifth emits just 2 per cent.

The report makes three principal recommendations:

- Include a comprehensive study of interactions between population and climate trends in the Third Assessment Report of the Intergovernmental Panel on Climate Change, expected to be published in the year 2000.
- Integrate into climate agreements the social investments called for in the Programme of Action of the 1994 International Conference on Population and Development, noting their potential to support and amplify other measures aimed a slowing and eventually halting human-induced climate change.
- Focus on the limited use of the global atmosphere for disposing of greenhouse gas emissions as a human right that should be allocated equitably among nations, perhaps through an emissions trading system that compensates nations whose per capita emissions are low.

According to Robert Engelman, author of the report, massive improvements in energy conservation and a global shift to low-carbon and carbon-free sources of energy are needed to shrink global greenhouse gas emissions. Slower population growth – and an eventual end to that growth – will allow for a world in which per capita emissions are much more equitable than today, yet compatible with both a stable climate and modest, continuous use of fossil fuels while supplies last.

For a copy of the report, *Profiles in Carbon: An Update on Population, Consumption and Carbon Dioxide Emissions*, contact: Sally Ethelston, PAI, 1120 19th Street NW, Suite 550, Washington DC 20036, USA. Tel: (+1 202) 659 1833, Fax: (+1 202) 293 1795, Email: sae@popact.

SPREADING HUNGER

There are more hungry people in the world than there were at the beginning of the decade, according to *The State of Food and Agriculture 1998*, published by the FAO. According to the report, there were 828 million chronically malnourished people in the developing world in 1994-96, 6 million more than estimates for 1990-1992.

The main reason for the increase is because there has been little progress in reducing poverty, according to FAO. Other causes were weather-related crop damage and foreign exchange constraints preventing the import of food to make up the domestic shortfall. Overall, the percentage as a part of the world population has declined over the same period from 20 to 19 per cent, but this has not been sufficient to compensate for population growth.

"If you look at the world as a whole, there is enough food produced to feed each person, each day," said John Lupien, Director of FAO's Food and Nutrition Division. "But it isn't happening because it's access to food that's the real problem."

If the available food were distributed according to need, it would be sufficient to feed everyone in the world, providing 2,720 calories per day. But the reality is that 17 countries have severe food supply problems, with a daily energy supply (DES) of less than 2,000 calories. A further 37 have DES levels between 2,000 and 2,299 calories.

The report warns that global financial turmoil now threatens the earlier economic gains, including improved food security, made by many Asian and Latin American countries. Its negative effects on household incomes, employment and prospects for agricultural production and trade could lead to greater food insecurity for millions of people.

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Email: publications@fao.org

ENERGY FAIR

Sustain ,99, the largest international sustainable energy trade fair in the world, will be held in Amsterdam from 25-27 May. Exhibits and workshops will include renewable energy, waste-to-energy, energy efficiency and sustainable transport. See website: **www.emml.com** or contact: European Media Marketing Ltd, PO Box 259, Bromley BR1 1ZR, UK. Tel: + 44 (0) 181 289 8989, Fax: + 44 (0)181 289 8484, Email: sustain@emml.co.uk

TRAPPING 'NEVER BENIGN'

I cannot but take strong exception to the short article headed 'Benign Trapping' in Vol 7/4 of your magazine.

Ecology and ethics are unseparable. Ecologists cannot do without being ethical. They cannot justify ecological aims by unethical means. It imposes unbearable suffering on millions of sensible living beings. It is never "benign". On the contrary, it is always cruel.

Trapping is contrary to elementary ethics.

Caring for species cannot exclude caring for individuals. This applies to humans and non humans alike. If the Canadian Government allows trapping for economical reasons (mostly by "First Nations"), we cannot welcome it by saying that it does not affect species (even if this proves to be true, as it probably is not). We must refuse it on ethical grounds, i.e. the enormous sufferings implied. We must insist on the use of more humane means. We cannot call it "benign".

Godofredo Stutzin
Member of IUCN Survival Service and Politics and Law Commisions, Member of UNEP's Global 500 Roll of Honour.

The Spanish city of Pamplona has long been known for its annual running of the bulls. But this mid-sized industrial centre, located in the rugged, hilly state of Navarra, is quickly gaining recognition for another kind of distinction: the world's fastest growing wind energy industry. Starting from scratch in 1995, the State of Navarra obtained 23 per cent of its electricity from the wind in 1998. The sudden transformation of Navarra's energy system over the past decade may turn out to be the leading wave of something much bigger. Around the world, new, carbon-free energy technologies that do not rely on fossil fuels are moving from experimental curiosity to commercial reality – economically turning sunlight, wind, and other renewable resources into useful forms of energy. Although the new devices still provide less than 1 per cent of the world's energy, they are advancing rapidly. Just what that could mean in the 21st century is outlined here by **Christopher Flavin** and **Seth Dunn** of the Worldwatch Institute.

Renewable energy c

It has been nearly a century since the world has had a comparable opportunity to change its energy system. Much of the system now in place was created in an explosion of invention that began around 1890 and was largely finished by 1910. Cities all over the world were transformed as automobiles and electric lights replaced horse-drawn carriages and gas lamps. Technologies that had prevailed for centuries became obsolete in a matter of years, and the 20th century emerged as the age of fossil fuels.

We may be at a similar turning point today. After two decades of waxing and waning public policy support, and a brief surge of market activity in California in the 1980s, renewable energy technologies are finally coming of age. Thanks to a potent combination of advancing technology and government incentives, signs of change are already evident in world energy markets. During the 1990s, wind power generation has grown at a rate of 25.7 per cent per year, while solar energy has grown at 16.8 per cent annually. During the same period, the world's dominant energy source – oil – has grown at just 1.4 per cent per year.

Wind and solar energy currently produce less than 1 per cent of the world's energy, but as the computer industry long ago discovered, double-digit growth rates can rapidly turn a tiny sector into a giant. In the past year, perhaps a dozen major companies have joined Shell in announcing major new investments in giant wind farms, solar

Solar energy complex, Mojave Desert, USA. Solar panels super-heat oil to power steam turbine generators.

manufacturing plants, and fuel cell development.

The 'alternative' energy industry is beginning to take on the same kind of 'buzz' that surrounded John D. Rockefeller's feverish expansion of the oil industry in the 1880s – or Bill Gates' early moves in the software business in the 1980s.

It is in the fields of electronics, synthetic materials, biotechnology, and software that a new energy system may already be gestating. The silicon semiconductor chip, for example, a technology that is less than four decades old, has made it possible to place 32 million transistors on one tiny chip, and has already been incorporated in nearly every industry. The increased processing power and miniaturisation of electronic devices make it possible to control nearly all energy generating and using devices more effectively and efficiently, and makes entirely new concepts possible.

Electronic controls have already reached from oil exploration to nuclear plant controls, but their impact has been most dramatic in a range of small-scale, modular technologies, such as wind turbines, photovoltaics, and fuel cells that would not have been practical without the ability to cheaply and precisely control them with the latest semiconductor chips.

Advances in metallurgy – such as sturdier, more heat-resistant steel – and mechanical engineering – such as spinning mechanical steam turbines – created much of the energy system on which we now depend. But in the decades ahead, breakthroughs in chemistry and materials science may call the tune, with a new generation of sophisticated, lightweight materials that do their job without the wear-and-tear of moving parts. Biochemistry, electrochemistry, and semiconductor physics could all play big roles as well.

As with the automobile and incandescent lightbulb before them, the solar cell and the electric car are entering larger and larger chunks of the marketplace and may soon be ready to contribute to a third energy revolution. They could foster a new generation of mass-produced machines that efficiently and cleanly provide the energy that enables people to take a hot shower, sip a cold beer, or surf the Internet.

comes of age

Hank Morgan/Science Photo Library

HYPERCAR IS COMING

Would you like a car that accelerates like a Mustang, contains no steel parts to rust away and travels 500km (313 miles) on a gallon of fuel? If so, you'll have to wait - but maybe not for very long.

Amory Lovins, the visionary Director of the Rocky Mountain Institute in Colorado, predicts that genuine first generation 'hypercars' will be on sale by 2004. And once they have arrived, he expects them to dominate the entire car market within a few years.

The hypercar concept is simple enough. Rather than pursuing incremental improvements in the design of steel cars that have remained fundamentally unchanged for 100 years, Lovins began again with the emerging technologies of the late 20th century – strong, lightweight composite materials, aerodynamic profiling, high-efficiency fuel cells, hybrid electric propulsion systems and regenerative brakes.

Barely one per cent of the fuel energy released in current car engines actually moves the driver and passengers. The rest moves the car itself, is wasted in the engine and drive train, or is lost in braking, air resistance and tyres slipping against the road. Start out again with new technologies and a hypercar will weigh a third as much as an ordinary car, perform just as well and cut 90 per cent of energy losses.

Although the hypercar concept was put into the public domain in 1993, a working model has yet to be built – partly a reflection of car-makers' reluctance to render obsolete their multi-billion pound investments in steel-bashing machinery. But they are now beginning to develop models that incorporate aspects of hypercar technology. And it can't be too long before one puts all those technologies together in one vehicle – and Bingo!

EV1 ELECTRIC

Oliver Tickell

Oliver Tickell is a freelance journalist specialising in the environment.

B&C Alexander/Still Pictures

The 21st century may be as profoundly shaped by the move away from fossil fuels as the 20th century was marked by the move towards them. Although it will take several decades for the new system to fully flower – shaped by the long lead times and massive investment entailed in today's system – the underlying markets could shift abruptly, drying up sales of conventional power plants and cars in a matter of years, and affecting the share prices of scores of companies. The economic health and political power of whole nations could be boosted, or in the case of the Middle East, sharply diminished. And our industries, homes, cities, and lives may be reshaped in ways we can only begin to anticipate.

But the stakes may be even greater than that. Our fossil fuel based energy system represents one of the central vulnerabilities of modern civilisation. By relying on rapidly depleting fuels – oil production is projected to peak within the next 10-20 years – and depending on the ability to release billions of tons of combustion gases into the atmosphere, we have built the economy on trends that cannot possibly be sustained for another century. How soon we pull off the transition may shape the lives of many generations to come.

The potential for wind and solar technology is now well understood. At 5-7 cents per kilowatt hour, wind power is already competitive with coal-powered plants and is expected to become even more so in the years ahead. Soaring markets are fuelling investment and driving costs down.

The cost of solar cells will need to fall by 50-75 per cent in order to be fully competitive with coal-fired electricity. But several companies are working on a new generation of thin-film solar cells, that are one-hundredth the thickness conventional ones, and will cut costs still further. Such technologies could take a serious bite out of the world's appetite for fossil fuels early in the next century.

But the technology with the most potential to reshape the world energy economy is the fuel cell. Roughly twice as efficient as conventional engines in converting chemical fuels to mechanical or electrical power, fuel cells are nearly as economical on a small-scale as on a large one. Moreover, they require little maintenance, are nearly silent, and emit only water vapour. Among other uses, they could power the transport systems of tomorrow.

Decentralising the system

The big question with all of these technologies is how long it might take for them to be competitive with fossil fuels, and how strongly industry interests will resist them. Many analysts are mesmerised by the large cost gap that remains, but they may be neglecting a principle that Henry Ford discovered when the century was young. Mass production allowed Ford to cut the cost of a Model T by 65 per cent between 1909 and 1923. Like the Model T, the new devices are small-scale, modular technologies, with markets that could be numbered in the millions. As their markets expand they could come down dramatically in cost.

The new technologies are at the niche stage today, but those niches are growing rapidly. Solar cells, for example, have gone from powering satellites and remote communication systems to a growing range of off-grid applications, including consumer electronic devices, highway signals and water pumps.

Now, a much bigger 'niche' is emerging: providing electricity for the 2 billion people in rural areas of Asia and Africa that do not have electricity. This market is growing rapidly and thereby fuelling investment, which will drive further cost reductions. Remote military bases, island resorts, and wastewater treatment plants are among the niches where fuel cells may soon gain a foothold; some companies are focusing on applying tiny fuel cells to cellular phones; they are half the weight and can supply 50 times as much power as conventional batteries.

As these examples suggest, one of the most far-reaching characteristics of the 21st century energy economy may be decentralisation – a reversal of the trend to ever-larger facilities, growing distances between sources and uses of power, which has led to extensive efficiency losses, both in the conversion and transportation of energy.

Contrasting today's monoculture of power generation, a distributed energy system might combine a range of new technologies – small turbines in factories, fuel cells in basements, rooftop solar panels, wind turbines scattered across pastures, and a new generation of ubiquitous energy storage devices

Above: Bathers in the warm outflow of a geothermal power station, Iceland. Right: Solar-powered telephone, USA. Below: Children watch TV powered by batteries charged by solar panels, Niger.

Mark Edwards/Still Pictures

that can be carried in a briefcase

In the coming century, our buildings, like those of ancient Rome, could – with the help of rooftop solar systems and fuel cells in the basement – meet most of their own energy needs. Automobiles and electric bicycles may one day be viewed as home 'appliances' that can be filled with hydrogen or electricity during the night. Architects now talk of "zero net energy" buildings that employ passive solar architecture and are so tightly designed that the bodies of the occupants provide much of the heating.

Although much of our energy may be harnessed or converted within cities by the middle of the next century – surveys show that covering the available roof space with solar cells could meet half or more of many cities' electricity needs – this alone will not suffice. Urban power will need to be supplemented by energy that is gathered from the world's croplands, deserts, and oceans, and piped to cities.

Wind power may be the first of these to be harnessed on a large scale. In the next century, a growing number of agricultural landscapes are likely to be sprinkled with wind turbines; in windy regions such as Patagonia, the American Great Plains, or the steppes of Central Asia, wind farms could churn out vast amounts of electricity. In China, the wind resource base has been conservatively estimated at 350,000 megawatts, sufficient to provide all of the country's electricity today.

In addition, the world's deserts can be covered with photovoltaic cells arranged into desert power stations that turn sunlight into electricity and hydrogen. Among the areas of the world that could get large amounts of power from such systems, prime candidates are North Africa and the Middle East, north-western India, western China, northern Mexico, and the south-western United States.

Four other energy sources may have an important role to play in the energy economy of the 21st century. Geothermal heat is found deep in the earth, and new technologies allow it to be used directly or tapped for electricity generation by channelling the steam to a mechanical turbine that spins a generator. In Iceland, geothermal energy already heats most of the country's homes. Among the other countries that have a large potential are Mexico, the Philippines, and the United States.

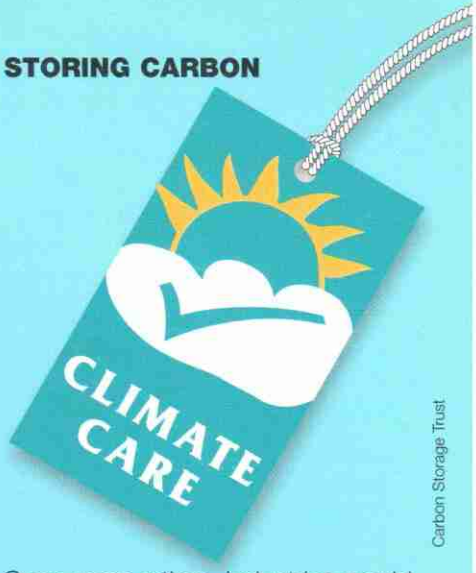
As Denmark has shown, biomass provides another ready source of energy. Agricultural wastes, ranging from sugar cane bagasse to rice hulls, can be gasified and turned into combustible fuels or electricity. Ethanol from sugarcane already supplies half of Brazil's automotive fuel.

The energy embodied in the ocean's tides, waves, currents, and

John Miles/Panos Pictures

• into the future • into the future • into the future • into the future •

STORING CARBON



Carbon Storage Trust

Once upon a time, industries would freely belch, spew and dump hazardous wastes, despoiling the human and natural environment. But that all came to an end years ago, didn't it? In modern industrialised countries, anyway? Think again.

As the main gas responsible for global climate change, carbon dioxide is definitely a hazardous waste. And Kyoto and Buenos Aires agreements notwithstanding, CO_2 emissions remain uncontrolled throughout the world.

"People are used to the idea that waste has to be managed," says Mike Mason, director of the UK-based Carbon Storage Trust (CST). "But somehow CO_2 got left out, and that's what we need to change. We are in business to manage people's CO_2 emissions in return for a fee – to see that it is safely and responsibly dealt with."

The CST has two principal carbon offset strategies. The first is to absorb CO_2 emissions through afforestation projects – taking care to use native species on deforested, agriculturally marginal landscapes, working with local people to generate collateral social and biodiversity benefits.

The second is to support energy efficiency and renewable energy projects which would not take place without such support. Products whose associated CO_2 has been offset by CST can then carry its 'Climate Care' logo.

After initial suspicions environmental groups such as the World Wide Fund for Nature, Greenpeace and Friends of the Earth are warming to CST's ideas. But they insist that while appropriate afforestation is desirable, it offers only a finite opportunity for carbon sequestration and should be accompanied by efforts to minimise CO_2 emissions at source.

Oliver Tickell

The first fuel cell-powered bus by Daimler-Benz which uses hydrogen as the source fuel.

DaimlerChrysler

temperature differentials may also be tapped. Two sizeable tidal power installations are already in place, but the other ocean energy technologies are still at an experimental stage.

Hydrogen economy

Most of the emerging renewable energy sources are by nature intermittent – and may not always be available when needed. In the early years of development, when these energy sources are contributing less than 30 per cent of the power in a given region, existing electricity grids generally have enough generating capacity to ensure reliability. But as these new energy sources become increasingly dominant, the system as a whole will need to be adapted.

The simplest solution is to build backup generators employing efficient gas turbines or pumped water storage; new technologies such as compressed air, plastic batteries, flywheels, and other storage devices also have a role to play. But the real key to a reliable, diversified energy system that depends heavily on renewable power supplies is to deploy hydrogen as a major energy carrier and storage medium.

The logic of a transition to hydrogen – the simplest and cleanest of fuels – has been argued by scientists for more than a century. In fact, as early as the 1870s, Jules Verne wrote that hydrogen would be a good substitute for coal. As often, Verne was ahead of his time; the technologies for efficiently moving, storing, and using hydrogen were not yet in place. But recent research in the space programme and elsewhere has shown that hydrogen can be safely harnessed, transported and stored. The streets of Chicago are already traversed by a fleet of buses with hydrogen tanks on their rooftops.

Serious development of hydrogen-based energy systems awaits one major development: low-cost fuel cells. The hydrogen for those initial fuel cells will probably be derived from natural gas, since splitting water using electrolysis is currently far more expensive. This would allow a hydrogen pipeline system to be built up gradually, piggy-backing on the natural gas system already in place.

Technologists are already exploring the possibility of developing small-scale units that convert natural gas to hydrogen, and could be placed in service stations. The carbon dioxide released from this conversion would be far less than is released from today's internal combustion engines, and if desired, the carbon produced by the reformers could be sequestered – either in some kind of product or perhaps in underground or undersea reservoirs.

Natural gas is more abundant than oil, and has been less heavily exploited so far, raising the prospect that it will be the dominant energy source early in the next century and could form a kind of 'bridge' to hydrogen. In fact, hydrogen might be mixed with natural gas and carried in the same pipelines, shifting later to new pipelines that are designed to carry pure hydrogen.

This would allow a relatively seamless transition. In the future, large amounts of hydrogen could be produced in remote wind farms, solar stations, and ocean power plants, and stored underground. Homes could produce some of their own hydrogen, using rooftop solar cells, storing it in the basement.

Like the rise of industrialisation and the fossil-fuel economy, the growth of the hydrogen economy and its enabling technologies could become self-reinforcing. As Princeton University physicist Robert Williams has put it, "If we start to take hydrogen seriously, we could be in for some surprises."

A shift to renewably produced hydrogen could leave behind some

of the 20th century's more unfortunate phenomena: oil-price induced financial meltdowns, and wars over petroleum.

The coming revolution

Like the computer industry, with which it shares many technologies, the clean-energy business is being led by dozens of entrepreneurial start-up companies, many of them financed with venture capital. But as business has boomed in the past two years, major corporations have jumped in. British Petroleum and Royal Dutch Shell are among the major oil companies that have recognised that oil's future is limited and so have stepped up their investments in renewable energy technologies.

How quickly the world's energy systems are transformed in the next century will depend in part on whether fossil-fuel prices remain low, and whether the opposition of many oil and electric power companies can be overcome. The pace of change will be heavily influenced by the climate agreement reached in Kyoto last year and the national implementation plans that follow.

In the 1980s, California provided tax incentives and access to the power grid for new energy sources, which enabled the state to dominate renewable-energy markets worldwide. Similar incentives and access have been offered by European countries in the 1990s. Such measures can begin to overcome the momentum of a century's investment in fossil fuels.

Although many economists argue that it will be difficult or expensive to find an alternative to oil and coal – and that we should delay the transition for as long as possible – their position is based on a technological pessimism that seems out of place today. The first automobiles and computers were difficult to use and expensive, but the pioneers persevered, made improvements, and ultimately triumphed in the marketplace.

Just as automobiles followed horses and computers displaced typewriters, so can the advance of technology make today's smokestacks and cars look primitive, inefficient, and uneconomical. The challenge of the next decade is to accelerate this incipient energy revolution. ■

Christopher Flavin is Senior Vice President and Seth Dunn a Research Associate at Worldwatch Institute, a private think tank located in Washington DC, that focuses on international environmental and resource issues. Flavin is co-author with Nicholas Lenssen of *Power Surge: Guide to the Coming Energy Revolution* (W.W. Norton, New York, 1994).

ENERGY MODELS

Egypt is among a group of developing countries which are experimenting with interactive software databases to help them decide on future energy strategies, *writes Gamini Seneviratne*.

The DECADES project launched in 1992 by five UN agencies and four other international bodies, has developed various generic databases which national planners can modify to meet local needs. The first of these measures the output of greenhouse gases, especially carbon, during the life of a power source (from the mining of raw materials to the final waste disposal).

The second enables cost comparisons to be made, with different weighting depending on the amount of $C0_2$ produced. The third provides data on present and upcoming technologies taking in their impacts on health and the environment.

Several countries, including Brazil, China and Egypt, are already using these tools beyond the experimental stage. Egypt, for example, aims to triple its installed capacity from some 13,000MW to possibly 37,000MW by 2025. With its hydro capacity (which provides a fifth of its power) effectively exhausted, it wants to move away from oil and much more into gas. It has plenty of sunlight and one particularly promising 80 sq. km area suitable for wind power. It is using DECADES tools in testing solar power plants (backed-up by gas at night) as well as wind potential; which may demonstrate how these renewables could be factored into the grid as competitive options in the future.

Gamini Seneviratne is a freelance journalist based in Vienna, Austria.

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The Renewable Energy Company

ENERGY TARIFFS

With the liberalisation of gas and electricity markets in the United Kingdom ordinary consumers can, for the first time, shop around for the best deals. Of course money comes first for most people. But given the choice of two companies offering similar prices, the environment can be the deciding factor.

So believes gas company Amerada, which has launched a 'Climate Care Saver' tariff, under which the Carbon Storage Trust is paid to offset all the carbon dioxide emitted when the gas is burnt – a sum of 0.119 pence per kilowatt hour of gas, plus £10 for each new customer. "The price difference alone is not always enough, says Caroline Harper, Amerada's Managing Director. Things are even more active in the electricity market. The South West Electricity Board is offering its 'Green Electron' tariff which, over the course of the year, matches consumption with generation from renewable sources in return for a banded premium on the quarterly standing charge equating to about 0.5p per unit. Northern Ireland Electricity has a similar 'Eco Energy' scheme.

Eastern Electricity has set up a trust fund for small-scale renewables development that consumers can pay into under its EcoPower tariff, which charges a 5 or 10 per cent premium matched by Eastern up to the first million pounds. And one specialist company has been set up – the Renewable Energy Company of Stroud in Gloucestershire – which aims to offer renewable electricity at near market prices by using generators embedded within local distribution systems, thus saving transmission costs.

"Green tariffs have the potential to make a big difference and boost the renewables development," says Friends of the Earth energy campaigner Anna Stanford. "But we cannot rely on the market alone. Continued government support for renewables will be essential."

Oliver Tickell

Winds of change

The serious development of wind power in modern times began in 1973 after the oil crisis shook the confidence of the developed world that oil was there for the asking. Now, 16 years later, wind power is the fastest growing energy source in several regions of Europe, with the United States and India following behind in total installed capacity. And the potential is enormous.

The origins of this revolution go back a long way. The first recorded use of wind to provide mechanical power was for irrigation in Persia over 1000 years ago.

In the 12th century an amazing flowering of windmill technology took place in England with the development of the horizontal axis wind turbine. This English technology spread to Holland, France and Germany during the Middle Ages. Tens of thousands of windmills were used to grind corn, pump water and saw timber.

Another upsurge in the use of wind power took place in the United States during the last century. The multi-bladed American type windmill was used in hundreds of thousands to pump water in farms as the 'West' was being opened up.

Then, in the 1970s and early 1980s research and development programmes grew up in the United States, Sweden, the United Kingdom and Germany with the goal of developing large multi-megawatt wind turbines. These all ended in failure because of the superficial understanding of the technology at that time. In contrast to this pursuit of 'gigantism' the Danes began with the establishment of small-scale community-owned wind turbines and moved gradually to larger sizes on a learning curve. This policy paid off tremendously as Denmark now provides a large proportion of the world's wind turbines and employs 12,000 people in this industry.

Technology

Wind turbines for electricity generation are essentially simple devices, though their design requires deep understanding of the properties of wind, aerodynamics as well as mechanical and electrical engineering.

The kinetic energy in the wind is intercepted by three or two rotating, slender blades. The action of these blades is to extract energy from the wind by slowing it down. This extracted energy first appears as mechanical energy on the turbine shaft and then as electrical energy from a generator coupled to the shaft through a gearbox.

The power in the wind is proportional to the cube of the wind speed, hence doubling of the wind speed results in an eight-fold increase in electrical power generated. Wind turbines are designed to stop if the wind speed becomes excessive and do not rotate if the wind speed is too low for useful energy extraction.

Wind turbines are usually congregated in wind farms consisting of a few or as many as one hundred machines. By installing several machines on a site the costs of connection to the electricity grid and the operation and maintenance costs are reduced.

Landscape

Modern wind turbines rated at around 1 MW are large structures. Typically, a rotor of 40 metre diameter is attached to a nacelle at the top of a 40 metre tall tubular tower. Not surprisingly their environmental impact has not pleased everyone.

Controversy over their appearance is fuelled by the fact that wind farms are usually installed on tops of hills which make them prominent. In the past, wind turbines were also rather noisy. However, recent research has resulted in much quieter machines therefore noise is now not a major environmental issue.

Jorgen Schytte/Still Pictures

Overall, major environmental bodies remain firmly in their favour. Opinion surveys carried out in areas where wind farms are installed consistently indicate a 70 to 75 per cent 'in favour' response with the approval rating increasing after the installation. The topic is an emotionally charged one. Some environmentalists see wind turbines as monstrous structures whilst others see them as elegant modern sculptures enhancing the landscape. The fact is that with wind turbines you get what you see. There are no insidious chemical or radiological emissions and their presence is a reminder of how natural forces can be benignly harnessed to provide us with energy.

Meanwhile, the cost of wind generated electricity continues to fall. In the United Kingdom in 1992 the average cost was around 7p/kWh whilst in 1998 it is 2.7p/kWh. This is lower than energy produced from oil, coal and nuclear power but higher than that from gas. This comparison does not take into account the environmental costs associated with fossil and nuclear fuels. Costs are likely to fall further as the technology matures and within a few years time it is predicted that wind will provide us with the cheapest electricity no matter what the source.

Expansion

Today, wind power is growing fast in several European countries, with over 5400 MW installed in the European Union by October 1998. The United States follows with 1700 MW and India with just under 1000 MW. The world potential of wind energy is enormous and capable of supplying the world needs several times over.

The feasibly exploitable potential is a lot less, but in many windy parts of the world it can easily provide 20 per cent of the energy needs: solar power, biofuels and water power together with wind energy are complementary and Shell predicts that by the middle of the next century they will be supplying half of our energy needs.

Almost every country in the European Union has plans for a substantial expansion over the next few years. The European White Paper on renewable energy published in November 1997 predicts that by the year 2010, 12 per cent of the energy in Europe will be supplied by renewables with wind energy contributing 40,000 MW. By the same year, Denmark is intending to supply 20 per cent of its electricity needs from wind.

Because of the densely populated areas in Europe, offshore wind farms are now being planned. Although more expensive than onshore the price of this technology is falling. The great advantage of offshore exploitation is that it is not subject to the same environmental constraints as onshore.

The future of wind power is bright. It is a sobering thought that a technology invented one thousand years ago will make a marked impact on our energy needs at the turn of the second millennium. ■

Leon Freris

Dr Leon Freris is visiting Professor of Renewable Energy at the Centre for Renewable Energy Systems Technology, Loughborough University, England.

Left: Wind park, Jutland, Denmark. The country is a leader in wind power.

NORTH WINDS

Out of Germany's 16 states Schleswig-Holstein is the most northerly, right next to Denmark with the Baltic Sea to its east and the North Sea to its west. It is here, in this exposed landscape, that a considerable part of Germany's national wind potential is located.

The first step towards realising this potential occurred in 1988 when a change of the state government brought in a shift to energy policy. From an emphasis on nuclear – there are in the region three plants of 2500 MW capacity – the focus changed to renewables. Wind energy was seen as a local source of electricity which could cover a substantial proportion of the state's energy demand whilst simultaneously phasing out nuclear power and meeting ambitious goals for CO_2 reduction.

The new government set itself the goal of meeting 20-25 per cent of the electricity demand through wind by the year 2010. This could require 1200 MW of installed capacity consisting of about 2000 wind turbines. To launch this programme the state government offered investment grants of up to 30 per cent per plant initially, falling to 6 per cent during the last year of the programme which is now phased out. This initiative was supported by the national Electricity Feed Law which encouraged private generation. The result has been extraordinary. The wind power capacity of 2 MW in 1988 has now reached 600 MW.

Schleswig-Holstein's success has come about through a co-operative spirit amongst the state government, the regional utility, local manufacturers, planners, farmers and environmental groups.

Leon Freris

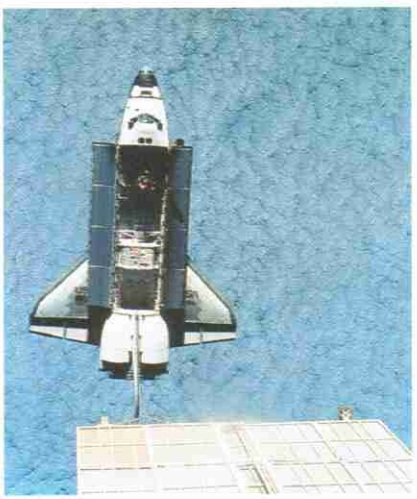
Thomas Raupach/Still Pictures

The clean car

"No car company will be able to thrive in the future with 100 per cent dependency on internal combustion engines." The speaker was the chairman of the world's largest car maker, General Motors, a company generally regarded as fairly conservative and not given to rash assertions. Thus, the comments by GM CEO John F. Smith two years ago at the Detroit Auto Show, predicting that environmental pressures will force a fundamental shift in the automotive industry by moving away from gasoline-fuelled cars to fuel cells, were seen as a sort of official seal of approval.

The development of fuel cells, these marvellous, silent, environmentally benign electrochemical engines that provide electrical power for the Space Shuttle, is moving ahead with a vengeance. For transportation, they are poised to become commercial realities for buses first and cars a little later. In stationary use, the race is on to develop efficient, economical plants for utilities, hospitals, office buildings and telecommunication networks; for computer systems, for providing cheaper, clean power to forsaken Alaska villages or remote Pacific islands.

Fuel Cells are about twice as efficient as internal combustion engines, and they are genuine zero-emitters when operating on pure hydrogen (think of hydrogen as natural gas minus carbon, the villain in the greenhouse gas carbon dioxide), very low pollution emitters and less efficient when running on low-carbon-content natural gas or methanol. All fossil fuels, though, can be seen as "hydrogen carriers" from which hydrogen can be extracted.



NASA/Science Photo Library

Around the world, about 150 small demonstration fuel cell power plants, rated at about 250 Kw each, are churning out electricity, mostly to gain operating experience. About 120 of them are of the phosphoric acid type, built by ONSI, a United Technologies/Toshiba joint venture. But other types such as molten carbonate, proton exchange membrane and solid oxide fuel cell plants are already being tested.

For transportation, the proton exchange membrane (PEM) fuel cell is the preferred type. It operates at fairly low temperatures, starts more easily and is easier to make compact enough to fit into a car, bus or truck. Germany's Daimler-Benz – now DaimlerChrysler – in concert with Canadian fuel cell pioneer Ballard Power Systems and recently joined by Ford, has been the acknowledged leader since the early 1990s when development began to take off. Japan's Toyota is a close second. Just about all other car makers, plus many upstart developers, are racing to develop fuel cell vehicles, including three-wheelers and scooters popular in Asia.

Conceding that there are still lots of technical problems to solve, many corporate heavyweights believe fuel cell cars should be commercially ready around 2004-2005 – at least technically. Those early models will probably be pricey: a Toyota executive has said he expects them to cost two to three times as much as today's gasoline-burners, and he does not expect them to be popular for another 30 years or so.

Costs are still a big issue indeed, less so for stationary power plants where investment outlays are beginning to approach commercial levels, particularly when aided by subsidies. But competing on the road is tough: the cost per kilowatt – or horsepower, if you prefer – of today's essentially hand-made fuel cells can be as much as 100 times that of the old reliable internal-combustion engine. Studies by GM and others predict, however, these numbers will come down to comparable levels with mass production.

In developing countries, fuel cells are likely to be tried first as low-polluting engines in urban buses. The United Nations Development Programme (UNDP) and the Global Environment Fund (GEF) are developing feasibility studies for Sao Paulo, Cairo, New Delhi, Mexico City and Beijing. Sao Paulo is furthest along, and proposals for a demonstration phase may be on the table this spring. China issued a request for proposals in early 1998, but scarcity of funds makes prospects uncertain.

What about the fuel? Hydrogen, one of the two components of water, H_2O, is by definition pollution-free – particularly when produced via solar energy and electrolysis from water. When recombined – "oxidised" – with the air's oxygen in a fuel cell, it returns to steam. But so far, it is hard to store on board. One proposed interim solution would be to extract hydrogen from fuels such as gasoline or methanol onboard the vehicle by a kind of micro-chemical plant. Proponents argue this makes

Main Picture: NECAR 3 developed by Daimler-Benz is the first-ever fuel cell powered car that uses methanol as the source fuel.
Bottom left: Fuel cells provide electrical power for the Space Shuttle.

DaimlerChrysler

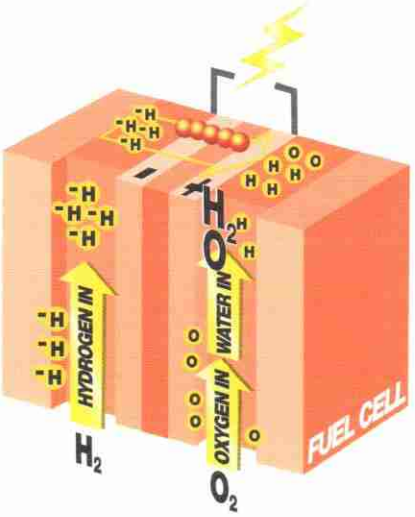
is coming

sense because fuel infrastructures exist for most of these fuels almost everywhere – but not for hydrogen. However, pure hydrogen is the environmental "gold standard," as California's recent tougher anti-pollution rules put it.

As to costs, some experts argue that while the cost of hydrogen extracted from fossil fuels would be about twice that of North America's perversely cheap gasoline, it would be just about offset by the fuel cell's better efficiency. Others maintain the cost of the extra "reforming" machinery both on the vehicle and at the station would be higher than for a hydrogen system, making "pure" hydrogen vehicles more attractive even now.

The bottom line is that clean cars and power plants will become affordable and feasible, but it will take a while. A cleaner environment, a more stable climate via reduced carbon dioxide in the atmosphere, lower public health costs because of less soot, smoke, unburned hydrocarbons and particulates to breathe will be the payoff. ■

Peter Hoffmann



The fuel cell car engine creates electricity from hydrogen, and oxygen in the air, through an electrochemical process that forms only water and heat as by-products. The hydrogen can be stored on the vehicle or extracted through thermochemical processes from natural gas methanol, gasoline or ethanol or other hydrogen carriers.

Peter Hoffmann is editor/publisher of the international *Hydrogen & Fuel Cell Letter* (website: www.mhv.net/~hfcletter). A former foreign correspondent for McGraw-Hill World News/Business Week in Bonn and Milan, he is revising his 1981 book, *The Forever Fuel - The Story of Hydrogen.*

SACRAMENTO'S SUN

In the United States, solar power has received a boost from a locally-owned electric utility in California. The Sacramento Municipal Utility District (SMUD) launched its PV Pioneers Program in 1993. Each year, the utility buys about 100 solar systems and installs them on area homes, where they feed power into the electrical grid.

The utility retains ownership of the solar panels. And homeowners pay an extra $4 each month for the privilege of hosting this clean energy source. Already, the utility has installed 5.7 megawatts' worth of grid-linked solar panels on more than 420 homes and buildings, and above several parking lots. Another 10 megawatts are scheduled between 1998 and 2002.

To meet this goal, SMUD initiated the second phase of its solar program, PV Pioneers II, in 1998. Now SMUD sells grid-connected PV systems to interested homeowners, and buys back the electricity produced by their roofs. "Net metering" makes this transaction possible: the rooftop's output is subtracted from the customer's use of power, so at the end of the month, the customer pays a utility bill that covers the "net" electricity used. The systems supply 20-80 per cent of a household's energy, so customers can expect much lower bills. To help sustain the program, SMUD has signed a long-term contract with a solar manufacturing company to begin producing cells locally.

Molly O'Meara

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Bringing biomass up-to-date

Mark Edwards/Still Pictures

There is now nearly-universal recognition that wood and other vegetation is an important source of energy. Altogether biomass supplies 14 per cent of all the energy used in the world. In developing countries it is the single most important source providing more than a third of all the energy used.

In total, the use of biomass is not declining, though growing world population means that there is less of it to go round on a per capita basis. Indeed, the World Bank stated in 1996 that "energy policies will need to be as concerned about the supply and use of biofuels as they are about modern fuels."

In this situation, it is crucial to ensure that the mostly traditional use of biomass is carried out in the most environmentally and health-friendly way, using improved stoves, charcoal kilns, steam plants and other methods.

At the same time biomass is being actively promoted in a number of countries as an environmentally friendly fuel, which does not increase the level of carbon dioxide in the atmosphere, and is low in sulphur, so that it does not contribute to acid rain. This is happening, for example, in Scandinavia, Austria, USA and UK, where regulations, carbon taxes and incentives are promoting biomass to high per capita use levels.

Indeed, a number of studies by the International Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), Greenpeace and Shell Oil have all predicted a major role for modernised biomass in the next century.

Of course, biomass is not a perfect source of energy: but it is probably "more perfect" than most other sources. To be available in reasonable quantities for community and industrial use, it requires land for agriculture and forests, as well as transport and conversion into the solid, liquid and gaseous fuels.

All these operations must be part of a sustainable cycle which produces net benefits to local people, the country and the global environment. This is a stiff requirement which is hardly met by any other energy system where life cycle analysis and external costs of pollution and degradation are usually not considered. At least in the case of biomass it is possible to ensure long-term sustainability, with the right incentives for sustainable production and use. Groups in the United States, Europe, India and Brazil have proposed guidelines for producers and users to encourage communities and agroindustries to accept the necessary disciplines.

In the past, questions have been raised about the sustainability of biomass energy systems. These have queried the net energy benefits, the food versus fuel priorities in land use, the extent of land required to produce sufficient quantities of energy, the nutrient balances, and the effects on biodiversity. All these concerns have been answered over the last decade or so by small and large scale bioenergy systems from all around the world.

Successful examples have come from Austria with district heating, Brazil with sugarcane ethanol and industrial charcoal plantations, China with family biogas digesters, India with mixed plantations for gasifiers for local electricity production, Sweden and Finland with combined heat and power from forest residues and now new large scale gasifiers, the United States with industrial scale electricity production using all types of residues, and from Zimbabwe, Kenya and Malawi, where ethanol is being produced for transport fuels. Hopefully in the next century ethanol and methanol will be produced from woody plants.

It should, in the future, be possible to adapt such experiences to local requirements in many different settings, although this is often easier said than done because of the very diversity of options and requirements.

With the onset of the Kyoto Protocol to ameliorate global warming the future use of biomass takes on a wider role. It has been recognised, for at least a decade, that growing and using biomass on a continuous basis as a substitute for fossil fuels has clear advantages compared to using the biomass solely as a means to sequester (store) carbon to create a carbon sink.

The biomass is grown perennially to generate energy so that environmental benefits such as soil conservation and biodiversity protection accrue in comparison to annual crops. In addition, rural communities gain jobs rather than losing them when land is removed from productive use, simply to sequester carbon.

Naturally, where mature forests exist they should be conserved as both carbon sinks and deposits of biodiversity. Also, where biomass energy plantations are grown – probably on degraded and excess arable land – they must follow ecological guidelines to serve the same purpose. ■

David Hall

David Hall is Professor of Plant Biology at Kings College, London, and author with Dr H. N. Ravindranath of *Biomass, Energy and Environment*, published by Oxford University Press (1995).

Markets surge for sun's energy

George Porter, the British Nobel laureate in chemistry, once said, "If sunbeams were weapons of war, we would have had solar energy long ago." Indeed it was the Cold War space race of the 1960s that spurred the development of photovoltaic (PV) cells, the thin silicone wafers that turn sunlight directly into electricity. Today the same characteristics that make PVs ideal to power space craft – light weight, modular, and no moving parts – are helping solar cells to compete on land.

Although still tiny by energy industry standards, the world market for solar cells more than doubled from annual sales of about 70 megawatts in 1994 to 160 megawatts in 1998. About half the market is for remote non-residential uses such as highway signals, radios, water pumps and purification systems, where the most common alternative is a high-cost diesel generator. Another 20 per cent goes to small consumer products such as calculators and watches. Unlike most energy technologies, solar cells can be used economically in such small devices.

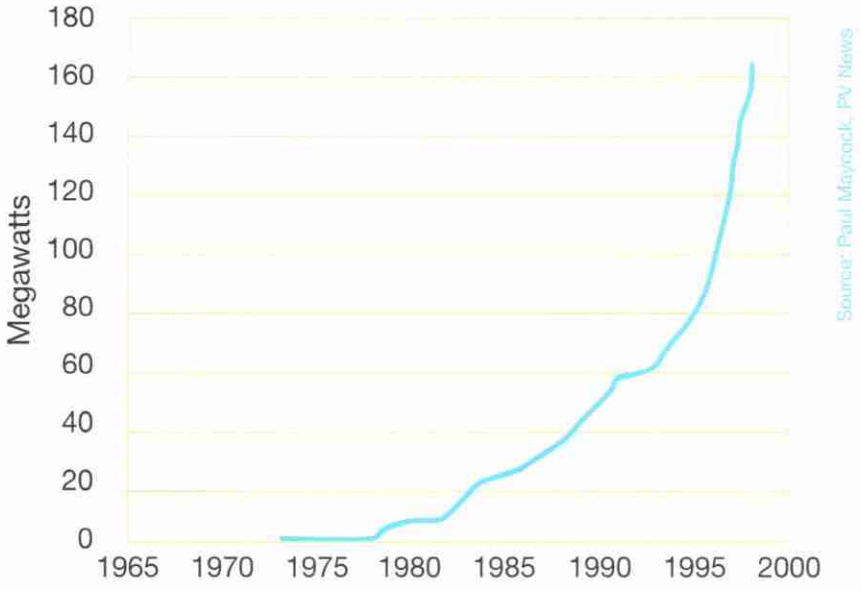
Individual residential solar systems account for the remaining 30 per cent. Solar cells have long been the most economical power source in remote parts of the developing world. Thousands of rural families in countries such as the Dominican Republic, Brazil, Indonesia, India, Morocco, and Kenya now have solar power. The systems are typically tiny – less than a square metre in size with a generating capacity of 20-100 watts – but life transforming. The clean light allows children to read at night, without the health hazards of kerosene fumes.

The isolated, mountainous areas that electricity lines do not reach are usually the places that phone lines shun as well. Thus, in much of the developing world there is the potential for the revolutions in energy and telecommunications to meet up. In the next decade, a new space race fuelled by 1,700 communications satellites, 10 times the number now in orbit, is set to transform the globalphone network. These satellites will be able to bring phone service and internet hook-ups to remote homes powered by PVs.

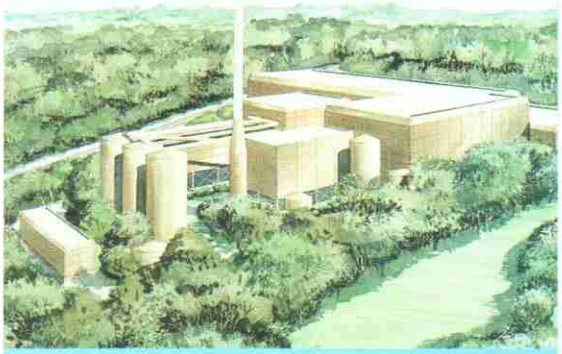
The 1990s have also seen thousands of solar panels hoised atop homes and office buildings in industrial country cities such as Tokyo, Berlin and Zurich – places that are already well served by an electrical grid.

In 1990, grid-connected homes

World Photovoltaic shipment, 1971 - 1998



Source: Paul Maycock, PV News



Fibrowatt

POULTRY POWER

The largest biomass-fired electricity generating plant in Europe has now begun commercial operation at Thetford, Norfolk, UK. Built at a cost of some £69m ($110m), the Thetford plant produces 38.5 MW of electricity (enough to supply 70,000 homes) from burning poultry litter (a mixture of straw, wood chippings and poultry droppings) to generate steam.

The plant and two smaller plants operated by the same company, Fibrowatt, are so far the only generating plants in the world using this fuel. Over 300 gigawatt-hours of energy will be exported annually to the national grid.

The Thetford plant will burn up to 450,000 tonnes of poultry litter per year. A nitrogen-free fertiliser, rich in phosphates and potash with trace elements, is produced as a by-product of the clean-burning technology. Among the environmental benefits are:

- The reduction of CO_2 emissions by recycling carbon rather than producing new CO_2
- The elimination of methane emissions from stored poultry litter reduces greenhouse gases
- Levels of noxious gases released, such as sulphur dioxide and nitrogen oxides, are a fraction of those emitted by coal-fired power stations
- Farmers are paid more for drier poultry litter – an incentive for them to improve the conditions under which they rear their birds.

The project has been financed by a consortium of banks and the debt will be repaid over 12 years on a straight amortization basis at a commercial interest rate.

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and buildings accounted for just 2 per cent of the market for PVs. By 1996 their market share grew to 8 per cent, but in 1997 it jumped to 21 per cent. In the United States, it now costs home buyers roughly $20,000 extra to buy a solar powered home – an option that would add some $100 a month to a typical mortgage. The actor Robin Williams has one, but he paid much more, since his home is not a modest one.

Government support is triggering the current boom. Japan has been the leader in recent years, providing generous subsidies to roof top solar systems. Between 1994 and 1998, some 12,000 customers took advantage of the government's cash subsidy for PVs, bringing the total of solar-powered homes in Japan to 25,000, generating 48 megawatts of solar power.

Spurred by the Japanese example and strong public support, both the United States and the European Union announced a Million Solar Roofs programmes in 1997. These programmes, which are still being formulated, are partnerships with state and local governments as well as the private sector and are intended to provide tax incentives, low cost financing and other assistance to those who want to use solar power.

In individual European countries, Germany, Switzerland, Norway and the Netherlands all have long standing solar incentives in place, and Italy has recently joined the club. Germany plans to launch the largest effort to date – a five year programme to build 100,000 rooftop systems. Already, the country hosts a number of high-profile solar installations, including a 1 megawatt rooftop power plant, the world's largest, which sits atop the halls of the new Munich Trade Fair Centre.

Solar-powered buildings are becoming easier to build, as PVs are now directly integrated into roofing shingles, tiles, and even window glass – turning ordinary construction materials into nearly invisible power generators. For example, Kawneer, an aluminium building material manufacturer, and Solarex, a maker of PV modules, teamed up to produce the 'PowerWall', which can be used instead of tinted glass or aluminium on building facades as a sun shade that also generates power. And a new pre-designed 'zero-energy house' from Misawa, Japan's largest homebuilder, is fully powered by a solar array that doubles as a roof.

Technological advances have driven down solar cell costs by 80 per cent since 1980, and further declines are expected, which may make solar electricity a potential competitor to fossil fuels. But in areas served by electric lines, solar power still costs 2-5 times that from the grid. Automated manufacturing, larger factories, and more efficient cells are expected to reduce costs in the near future.

Among the large new manufacturing plants announced recently are a 20-megawatt factory that BP Solar are building in Australia and a 25-megawatt plant by Pilkington Solar in Germany. And compared to conventional solar cells, the new 'thin film' cells use less raw material, which makes them cheaper. Moreover, they do not need to be sliced or rigidly encased and can be made into large, flexible sheets ideal for incorporating into building materials.

The latest surge in the PV markets suggest that solar power will play an important role in building a 21st century energy system that serves more people while polluting less. Solar panels are not only bringing light to some of the most inaccessible parts of the world but can also provide clean power in burgeoning cities. ■

Molly O'Meara

Molly O'Meara is a senior researcher at the Worldwatch Institute.

Solar-panelled housing, Tokyo, Japan.

J. Holmes/Panos Pictures

Harve the p

It seems ironic that new renewable energy projects such as wind farms or hydro installations often get opposed on environmental grounds; largely because the areas with high human populations which need this energy are precisely those where land space is at a premium.

Fortunately, over 70 per cent of the surface of the planet is covered by seas which are almost empty of human activity and which in themselves represent a huge energy resource. Until recently the seas were regarded as an environment human beings visited at their peril. But, within the last decade or two, technology has developed, largely driven by the wealth to be obtained from exploiting offshore oil and gas reserves, so that for the first time we dare to build large permanent structures intended to survive decades in this hostile environment. Before long, our need for massive quantities of clean energy will drive us in the same direction.

We are, in fact, at the start of exciting new developments in offshore renewable energy engineering, with a variety of practical marine renewable energy options to choose from. These are offshore wind energy, tidal/marine current kinetic energy, wave energy, tidal barrages and Ocean thermal energy conversion (OTEC).

Of these, only the first three seem to have serious prospects for commercial development on a large scale.

Off-shore wind

Off-shore wind is really a land-based technology moved out to sea. The sea only plays its part in offering better average wind speeds than are normally found on land, together with avoiding the conflicts over land-use inherent in setting up large wind farms on-shore.

The high cable costs and extra structural costs to withstand marine conditions make this more costly than land-based wind, but as techniques improve this option can be expected to play an increasingly important role in our future energy supplies. The North Sea in particular is likely to gain several thousand megawatts of offshore wind installations within the next decade, as

sting ower of the sea

without this the declared green house gas mitigation targets for Europe are unlikely to be met.

Marine currents

Marine currents are primarily caused by the motion of the tides; the gravitational attractions of the moon and the sun cause the surface of the oceans to bulge by a small amount and hence millions of tonnes of sea water flow continuously, mainly at rather small velocities. At a few places where the seabed and shore topography interact with this flow, these flows get speeded up.

Tidal currents with peak velocities in the range 4 to 8 knots are found in a quite a number of locations. Such high velocities represent a more intense energy resource than almost any other form of renewable energy (4 knots is a power density of about 4kW/m2) and it can be converted to electricity using an underwater turbine (in much the same way that a wind turbines works) with relatively high efficiency. Moreover this is a predictable resource, so its availability can be planned for with some precision in advance.

Work is proceeding on the development of marine current turbines which can be installed in groups under the sea, much like an underwater wind farm. Initial indications suggest that this technology could rapidly become competitive with more conventional methods of energy generation. Such turbines can be mounted on piles that are socketed into holes drilled into the seabed, or alternatively they may in future be mounted underneath moored pontoons.

Wave energy

Wave energy has been studied and experimented with for about 20 years and is proving quite difficult to take through to the stage of commercial viability. The main problem is that the energy is in the surface motion of the sea and it is the surface which is the most hazardous and difficult to place fixed equipment into. Corrosion and storm effects are at their most severe precisely where the wave energy device needs to be located.

There are three main categories of wave energy conversion devices, on-shore, near-shore and off-shore; on-shore devices built into the shoreline have been the main focus of attention so far as it is relatively easier to build a structure which can survive there.

The preferred mechanism is the Oscillating Water Column (OWC) where waves enter a chamber and the up and down movement of the surface pumps air backwards and forwards through a uni-directional turbine known as a Wells Turbine. Unfortunately, the energy availability in waves is least for on-shore and gets greater the further off-shore you can place the device, so the tendency will be to move the technology further out. To do so successfully demands larger and more robust devices than have so far been constructed, but no doubt these will eventually appear.

Other promising wave power devices are so called Point Absorbers, usually some form of buoyant device that moves up and down with the waves and transmits the motion to a suitable generator.

Tidal barrages

Of the remaining options, tidal barrages are limited to a few locations where the topographic features and the tidal range favour impounding of sea water at high tide behind a concrete wall, and to release it through turbines while the tide falls. However tidal barrages are not generally considered as economically viable at present and there is little interest in developing them.

Equally, the last option, OTEC, is only likely to be practical in tropical locations where the greatest temperature differences can be found between the surface of the sea and the deeper waters. It is this temperature difference which is essential to drive a thermodynamic process. Even in the Pacific Ocean where it is being tried, the viability of OTEC remains uncertain.

Nevertheless, we can expect to see energy from off-shore wind, from marine currents and from waves playing an increasingly important role in the forseeable future. ■

Peter Fraenkel

Julio Etchart/Still Pictures

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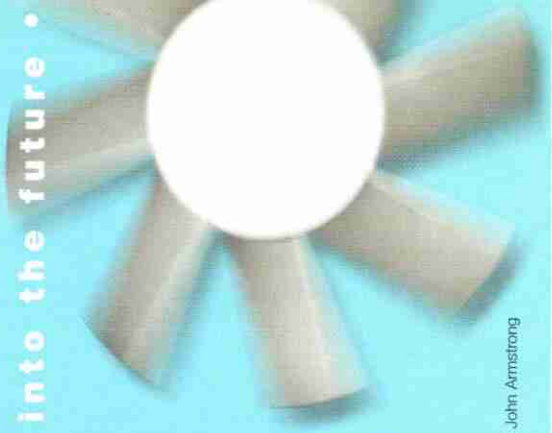

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TAPPING OCEAN CURRENTS

The world's first commercial scale marine current turbine, a system which functions rather like an 'underwater windmill' will develop a maximum of 300 kilowatts, about enough power for a small village.

This turbine is a concept patented by IT Power Ltd (a UK-based engineering consultancy), and will be installed on a steel pile which is socketed into the seabed. It will require a 15m diameter rotor to develop its rated power in a current of about 2.25m/s (or 4.5knots) and will be located in coastal waters off the south-west coast of England. The target date for commissioning the system is September 2000.

With support from the European Commission, the project is co-ordinated by IT Power Ltd and Seacore Ltd (a UK-based offshore piling specialist). Other partners are ITT Flygt AB (a Swedish manufacturer of submersible hydro turbines and pumps) and the IEE at Kassel University, Germany, (a research centre specialising in electrical machines, power electronics and fluid dynamics).

This machine is intended as the forerunner of an entirely new, clean energy technology. Indeed the planned second phase, to follow in 2002, will involve about 10 turbines each of 1MW and will produce power sufficient for a small town.

Marine current energy has a number of important advantages in addition to being clean and renewable, notably that the availability of the energy is accurately predictable (being based on the movements of the tides), the energy capture is high compared with other renewables, and the potential resource is extremely large with the potential to make a significant contribution to future energy needs.

Peter Fraenkel

More than 2,000 million people, many of them in the rural areas of the developing world, can see little prospect of being connected to a mains energy supply. But, as **Peter Fraenkel** explains, modern technology can help to fill the gap.

Energy beyon

Most of the electric power needs of people living in remote rural areas of the developing world are small. But these people are dispersed and they exist in large numbers – which is precisely why they are so difficult to satisfy.

As research shows, most of these energy needs can be met with power sources yielding 1kW or less, and it is rare to find stationary applications demanding as much as 5kW, let alone ten.

Unfortunately, the infrastructure for distributing conventional centralised mains electricity does not lend itself to serve dispersed populations with small energy needs economically.

By contrast, renewable energy technologies have the advantage of using resources that are readily available at the point of use, namely sun, wind, biomass or flowing water. They need little in the way of infrastructural and support costs.

It is true that a renewable energy system may produce energy at a relatively high cost compared with a large centralised power station, but this should be more than compensated for by savings on cables and connection costs.

Moreover, most of the lifecycle costs for a reliable renewable energy system is the capital investment. Running costs will generally be low as there is little need for consumables and no need for fuel supplies (other than those locally available in the case of biomass).

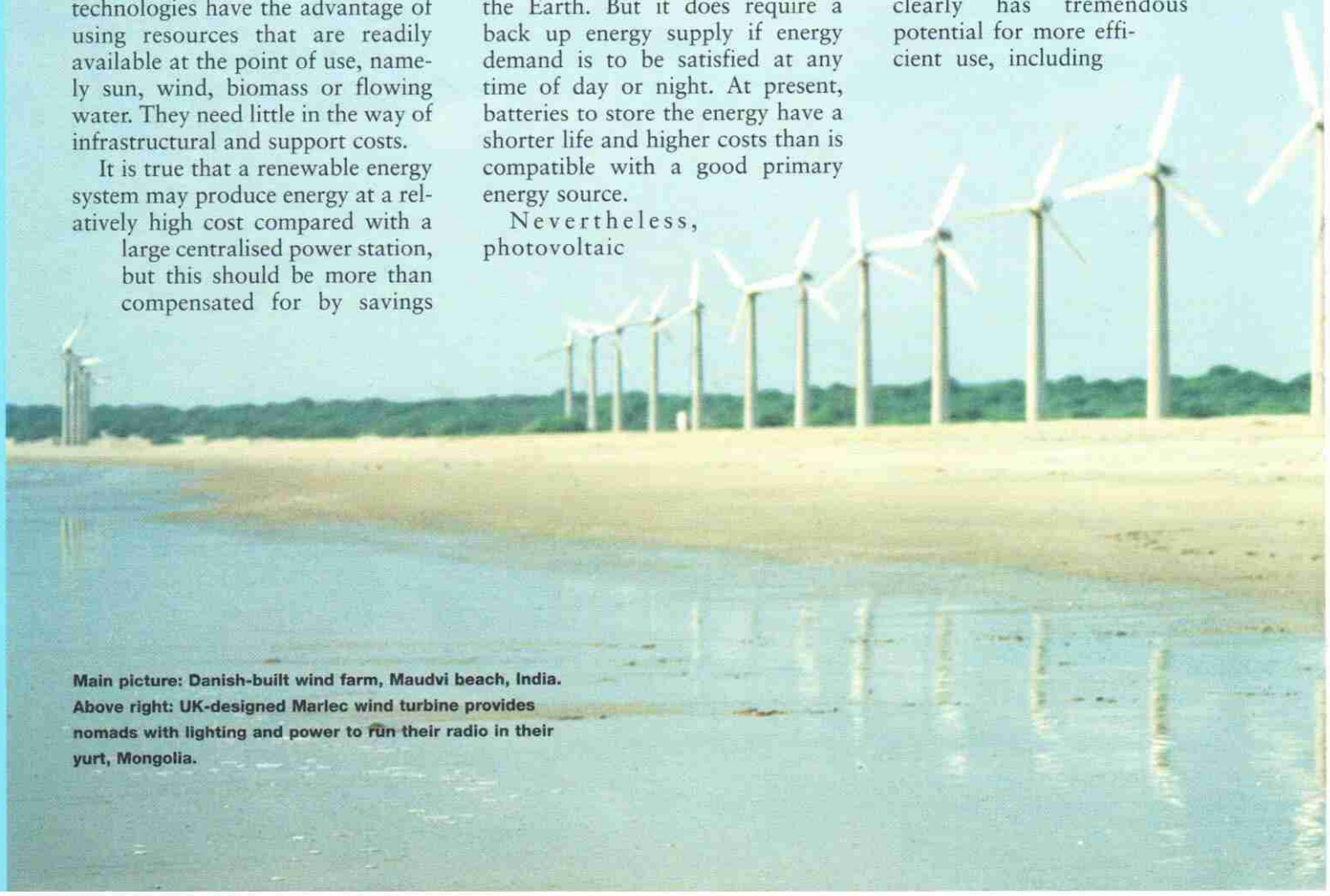
In some cases it may be possible to adopt conventional systems by extending the grid or using generating sets, run on petrol or diesel. But renewables could and should have a major future role to play if we are to have a reasonably uniformly civilised world.

Of these, solar energy is the least site specific being technically available over most of the land area of the Earth. But it does require a back up energy supply if energy demand is to be satisfied at any time of day or night. At present, batteries to store the energy have a shorter life and higher costs than is compatible with a good primary energy source.

Nevertheless, photovoltaic systems can improve lighting and provide access to radio and television at costs which are beginning to bear comparison with traditional sources of energy such as kerosene lamps, hurricane lanterns, candles or car batteries. World Bank research has shown that households often spend as much as $10 a month on such inefficient energy sources.

Wind is dependent on both local climatic conditions and terrain. Again, back up power supplies are generally essential, though in the case of wind pumps, water can be stored to provide a supply at times of little or no wind.

Biomass in all its various forms (solid, liquid and gaseous fuels) clearly has tremendous potential for more efficient use, including



Main picture: Danish-built wind farm, Maudvi beach, India. Above right: UK-designed Marlec wind turbine provides nomads with lighting and power to run their radio in their yurt, Mongolia.

Peter Fraenkel

d the grid

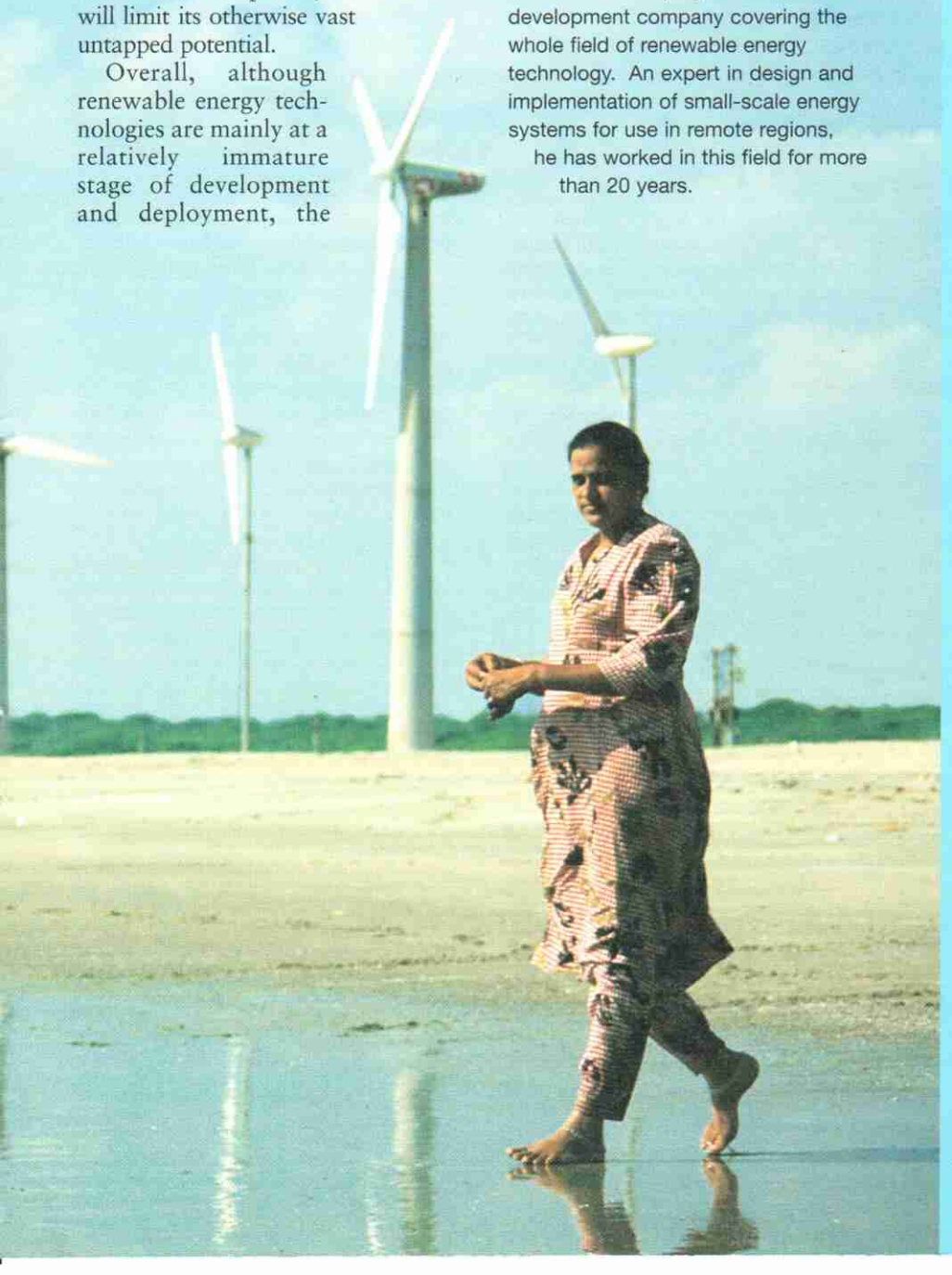
traction in internal combustion engines or improved externally-heated engines.

Hydro power is perhaps the most developed, reliable and practical renewable energy resource for delivering high levels of continuous power in rural areas, but it is also the most site specific, which will limit its otherwise vast untapped potential.

Overall, although renewable energy technologies are mainly at a relatively immature stage of development and deployment, the examples reported in this magazine are sufficient to show their scope. To recycle a well known advertising slogan: renewables will reach the parts that other technologies cannot reach. ■

Peter Fraenkel is Technical Director of IT Power Ltd (UK), a research and development company covering the whole field of renewable energy technology. An expert in design and implementation of small-scale energy systems for use in remote regions, he has worked in this field for more than 20 years.

Daniel O'Leary/Panos Pictures



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BIOGAS BONANZA

Thanks to the emphasis placed on 'newer' alternative energy technologies like wind and solar power in India, particularly since it liberalised its economy in 1991, traditional technologies have been somewhat neglected.

Biogas – the generation of gas from animal dung or farm and household wastes – is probably the best example of a time-tested technology which has not been given the credit it deserves. A National Project on Biogas Development was started as early as 1982 to promote household biogas plants. It aimed at providing a clean and cheap source of energy in rural areas, producing enriched organic manure (from the slurry) to supplement chemical fertiliser and reduce the drudgery women face in collecting fuelwood.

It was estimated that India could set up 12 million household plants, based on cattle dung. By 1996, 2.3 million had sprung up. The following year, the government set itself a target of 160,000 plants at a cost of US $11 million, which was surpassed with 171,000 units. Around 1,400 larger community sets have also been established. Together these plants have generated fuel gas equivalent to some 7.5 million tonnes of firewood, valued at $90 million a year.

Besides, these plants produce about 35 million tonnes of organic manure per year. Studies have shown that women who use biogas to cook with save about 3 hours every day by not having to forage for wood.

India's much-vaunted wind energy programme, with the third largest installed capacity in the world, has been boosted by very attractive tax breaks and other subsidies and incentives. As a result, many wind turbines have been erected, but fail to operate later. By contrast, the biogas programme is the tortoise in the race, but it is cheaper and can be installed by a middle- income rural household.

If this technology can be extended to operate with human waste from public toilets in smaller towns and larger villages, it will reduce the risks of contamination and improve hygiene considerably.

Darryl D'Monte

Darryl D'Monte is a freelance journalist and author specialising in environmental issues, based in Mumbai (Bombay).

Paul Quayle/Panos Pictures

Power for the people 1: **Bangladesh**

A new micro-credit scheme in Bangladesh is bringing solar-powered energy and fresh hope to the four out of five villages which remain beyond the national grid. **Lou Werner** reports.

Bringing light to the village

The brick path leads toward the darkened hamlet over an earthen berm, skirting fish ponds and rice paddies. Just as night is falling, a visitor passes under mango trees and close by the well worn backyards that children share with chickens, ducks, and water buffalo. Straw lies scattered across the way, left to dry under the baking pre-monsoon sun that tomorrow will surely bring.

Despite its timeless appearance, Shagur Dhigi Bazaar is unlike all but a few of Bangladesh's other 85,000 rural settlements. The fact that no cable runs in from the main road shows that it is among the four in five villages without a link to the national power grid. But, lying half a day's journey over back roads from Dhaka, that is not what makes Shagur Dhigi any different from its neighbouring villages in Tangail district.

Suddenly an electric light blinks to life in a market stall, and then another light comes on in the barbershop, and then a third in the pharmacy – all powered by electricity generated and distributed by a micro-utility. Since shopkeeper Shuntush Kumar Shaha installed his 75 watt photo-voltaic system, he has been renting out three bulbs to businessmen next-door.

Harun/Grameen Foundation USA

This is what sets Shuntush apart from the 100 million other Bangladeshis still waiting for the national power company to come to them. With the help of Grameen Bank, he went out and started his own utility.

Grameen is a pioneer institution in the field of micro-enterprise financing for the poor. Originally focused on agricultural, craft-making, and housing loans, it has lately started financing investments in solar, wind, and biogas power generation. In the next four years it hopes to have 4,000 systems in place.

The bank is unafraid of big challenges. Over the past two decades, it has extended loans, each averaging about $100 but amounting cumulatively to $2.4 billion, to some 2.3 million rural Bangladeshis. More than 90 per cent of borrowers are women, whom the loans help to empower through self-employment.

Grameen was founded in 1976 by Muhammad Yunus, then a Chittagong University economics professor who one day happened to meet a market vendor unable to buy 25 cents worth of cane needed to make sale items. When asked why she didn't apply for a bank loan, she laughed, and Yunus saw her point. Small loans could not turn a profit, went the conventional thinking, and very small loans were not even considered.

Yunus made the loan out of his pocket and then did a quick survey of her village. He found more than 40 small business people – vendors, farmers, and artisans – who could benefit from loans averaging less than a dollar. From this was born the idea of microcredit, and the ensuing belief that access to bank-credit should be recognised as basic human right.

While experts agree that the dynamism of entrepreneurship and self-employment is most easily tapped in traditional rural enterprises such as crafts and agriculture, Yunus is always thinking several steps ahead. "Why not go high-tech in the villages," he asks. "Telecom, the Internet, data processing. We're ready for it all. But first we need power."

"Technology today is different from what it was yesterday," he continues. "It's no longer the same inert hardware it was for first generation users. Now it's more like malleable clay, ready to be shaped at will. PCs have been trickling into South Asia for a decade, and many people still see them as toys. But photovoltaic cells are put to serious use overnight. And they are just the tip of the high-tech iceberg."

Not a charity

Yunus is such a believer in rural Bangladesh's capacity for high-tech ventures that in 1996 he founded a non-profit company named Grameen Shakti – shakti means energy in Sanskrit – to bring renewable energy to the countryside. Like Grameen's other speciality lines of business such as fish farming and handloom textiles, this new start-up relies on private sector banking principles: loan-making at financial rates of interest, full repayment, and professional service.

As Grameen Bank stakeholders, borrowers gain self-confidence and a broader world view. Being a full paying customer endows one with the right to good service and client responsiveness, things common in developed countries but often quite foreign elsewhere. "We are a bank," insists Yunus, "not a development project. We give loans, not charity."

Sawmill owner Muhammad Abu Hanif knows all about Grameen's strict accounting, as well as his own accountability to the bank. His loan for a one bulb 17 watt system came to more than $300 and required a 25 per cent downpayment, the balance to be repaid in two years at 8 per cent interest. But by operating at night, he has increased profits by 500 taka a day (US $10) and pays his four workers an additional 100 taka each.

Dipal Chandra Barua, head of Grameen Shakti and a chief executive of bank operations, sees magic in an illuminated light bulb. "People can do with electricity what they could never do with candle wax or kerosene," says Barua. "Study, work, make market sales – all things that sooner or later will bring them out of poverty."

The fact that most of Bangladesh

is dark and idle at night certainly does not help its national development. The country annually consumes only 17 litres of fuel oil per capita, one of the world's lowest rates, and meets 60 per cent of its domestic energy needs by burning cow dung.

There is no need to praise the benefit of electricity to the people of Dhalapara village, not far from Shagur Dhigi Bazaar. Grameen Shakti sales manager Abdu Salam Khan sold 30 solar energy systems in just four months, and their demonstration effect is widening demand by the day. "To light a kerosene lamp for just a few hours costs 25 cents for fuel," he says. "Why not pay half that for electric light all night long?"

Khan is referring to the kinds of micro-utilities operated by Shuntush and others like him. In Dhalapara village, Dibon Krishna Shahah rents three bulbs from a neighbour's 75 watt system. "My wife keeps up her tailoring business and my son stays at his school books a few extra hours each night," he says.

Grameen-designed systems consist of locally made components – charge controllers, florescent lamps, and 8 watt tubes – except for the imported solar cells themselves, which cost about $290 for a 17 watt panel and $750 for a 75 watt panel. If Grameen gets the right for local assembly, costs will come down $25 each. On the drawing board is a one lamp system for under $150.

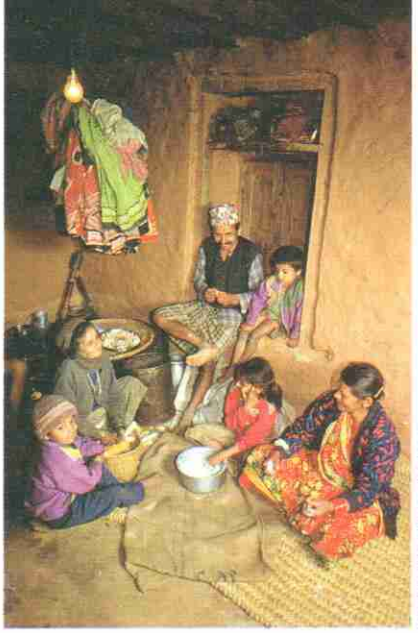
Even though Grameen Bank will finance these sales, the required down payment puts even the smallest solar system beyond the reach of the very poor. Some, like the employees of sawmill owner Abu Hanif, benefit from higher income possibilities, however.

Wider world

The availability of electricity has also improved the quality of certain kinds of work. Maneeq Mia owns an electronics repair shop in Dhalapara. His new 35 watt system allowed him to rig up a small fan to blow dust out of open casings and to exchange his kerosene heated soldering iron for an electric one. Now he takes on the more delicate jobs he once had to turn away.

Other things just cannot be done at all without an electric light. "My customers were afraid to let me shave them by the shadow of a kerosene lamp," says Shagur Dhigi's barber. "The razor is risky work. But with the bulb, I have 10 or 12 extra customers every night. Business is up 30 per cent."

And with electricity comes access to the wider world. After buying a 48 watt system, general store owner Ashis Kumar Shahah put in the village's only phone, which he rents out to the public at 20 taka/minute. The lack of electricity previously precluded a link up with the Bangladesh Rural Telephone Service.



Caroline Penn/Panos Pictures

Left: Muhammad Yunus
Above : Farmer's family use electricity generated from micro hydro power, Nepal.

The economic benefit of renewable energy is clear-cut even to teenage Alam Hussein, who keeps shop for his mother in Petcherata Bazaar. The family used to pay 300 taka a month for kerosene to light the store until 10 at night. The new 17 watt system now powers two 6 watt bulbs and a cassette player. Their 13,000 taka investment will pay for itself in kerosene savings in just three years.

Alam shakes his head sadly when a customer steps up to buy a pair of 'D' cell batteries for 26 taka. He will have to throw them away in just a week or two," he says, "while our system will be working for another 20 years."

The residents of Polashpur village in Keranigani thana are perhaps the ideal target market for the kinds of technology Grameen can deliver to the countryside. Although just across the Buriganga River from Dhaka, Polashpur has hope neither of a link to the power grid or to a telephone line. But now, for just over $1,000, an enterprising villager could buy himself a cellular telephone and household solar system with which to charge it, both sold and financed by Grameen.

"I've never used a telephone," says Polashpur widow Zahir Begum, "and I have to buy a lot of batteries to record the cassettes I send my brother in Kuwait. But if I had electricity, I wouldn't care so much about calling Kuwait or playing music. No, I'd rather have light in my house to work at night, and call Dhaka for the latest price of rice. Now we have to accept whatever the middleman offers, because here we are always in the dark." ■

Lou Werner is a New York-based documentary film-maker and health education media consultant.

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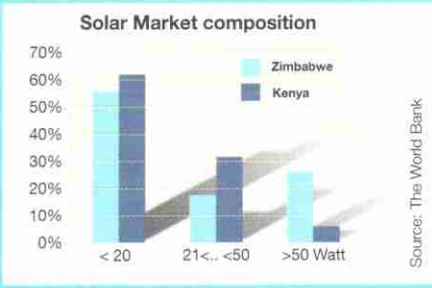
LESSONS FROM AFRICA

There are many lessons to be learnt from the 150,000 households in Kenya and the 80,000 in Zimbabwe that already purchased a solar system.

With market penetration rates of 3 per cent or more, and with each at least 2-3 MW solar capacity installed, both Kenya and Zimbabwe stand out in the state of the art of solar market development. This was mainly driven by private sector initiatives and, above all, by demand from rural and peri-urban households.

The illustration below shows the solar market characteristics, based on a survey of 410 households with a solar system in Kenya and preliminary data of a 6,000 household survey in Zimbabwe carried out last year. It clearly shows that the main solar market is for small systems of 10-15 Watt. In 1998 Kenya imported about 0.5 MW, of which at least 60 per cent consisted of these small amorphous modules. The contribution of systems larger than 50 Watt in Zimbabwe (lacking in Kenya) is probably the result of the multiyear, subsidised effort by GEF/UNDP in that country.



Many households construct a solar system in small components over several years. Although this might seem sub-optimal, it does allow for households to have faster access to the amenities of modern life than when they have to wait for a project to help them acquire a full solar home kit. Before moving up to a solar system, about half of the households in Zimbabwe used to take a car battery to a charging station once a week (this is very common in Kenya also). Households can add a solar module to their battery system once they have saved enough cash. With their solar system, half the users in Zimbabwe still need a battery boost, but less than once a month.

The private sector market development in both countries is driven by the desire to be part of modern life – using television, electric lights, and radio. A TV was used by respectively 71 per cent and 89 per cent, and a radio by 92 per cent and 70 per cent in Zimbabwe and in Kenya. It is seems that for many to be connected to the larger world by television is an important incentive to own a solar system.

Robert van der Plas

Robert van der Plas is an Energy Planner with the World Bank's Energy, Mining, and Telecommunications Department. This article reflects the views and opinions of the author, and not necessarily the views of the World Bank Group.

Power for the people 2: **Ethiopia**

Cooking pancakes

Cooking *injera* – Ethiopia's staple flat bread – is one of the most inefficient forms of energy use in the world. Now, after numerous attempts, a new improved stove, that could cut firewood use in half, is a big commercial success. **Mike Bess** reports.

Like nearly all Ethiopian wives, Alegnesh Alemayehu, spends several hours, twice a week, baking the flat pancake-like bread that is the everyday food for her family.

In the past she would have had to find around 10 kgs of wood for each baking session, or around 80 per cent of all the household energy consumption in the typical Ethiopian home. In a country with shrinking woodlands, the ton or more of fuel needed each year has meant ever-longer searches for firewood.

Now, however, Alegnesh has a new stove which uses half the fuel and creates much less smoke in the house: a major cause of respiratory disease in Ethiopia.

Called the Mirte it is the result of a long search over the last two decades by government and development agencies for a stove which would cut down on the use of biomass, which provides 80 per cent of all the primary energy used in the country.

Normally *injera* is baked using a ceramic flat plate (*mtad*) over a three stone fire with an energy efficiency of around 7 per cent under normal conditions. The new improved stove is not only twice as efficient, it has also been successfully commercialised and holds great promise for addressing Ethiopia's severe wood shortages in the very near term at relatively little cost.

Numerous attempts were made between 1979 and 1994 to improve biomass *injera* baking. Traditional baking not only consumes large quantities of fuelwood, but also poses major local environmental and health hazards. Burns and smoke inhalation are the most oft-cited complaints from *injera* cooks. These early attempts failed for a variety of reasons, primarily through lack of sufficient attention to the marketplace.

Improving *injera* baking is further complicated by the fact that traditional baking involves use of different fuels (branches, leaves, sticks and sawdust being the most preferred). Finally, during the mid-1990s, a World Bank-supported programme with the Ministry of Mines and Energy developed a low-cost, easily fabricated enclosed stove. It was designed with the assistance of John Parry Associates of the UK, and named the Mirte by a number of Ethiopian housewives in 1994. Stoves are produced using a simple metal mould to fabricate four main pieces produced from various cement mixes. Virtually any material from sand to volcanic pumice can be mixed with cement to form the stove body, and the stoves can be produced by any artisan with very little investment and training. The traditional *mtad* is bought separately and rests on top of the Mirte. A small chimney piece removes smoke from cooking areas.

The British Department for International Development (DFID) supported the commercialisation of this improved stove from 1995 to 1997. During this period, a number of workers were trained, several micro-credit revolving funds were established, and over 27,000 of the stoves were produced privately and sold commercially for an average price of US$5 per stove, with no subsidies or direct market interventions. The DFID programme was used to train artisans, monitor and evaluate the stove's performance, promote the stove, and disseminate it to a number of towns throughout Ethiopia.

So far, over 90,000 Mirte stoves have been sold in Addis Ababa and a number of smaller urban and rural areas, leading to wood savings of over 45,000 tons each year, and an estimated cumulative woody biomass savings of over 80,000 tons.

The Mirte reduces woody biomass consumption by 50 per cent in households, and more under commercial *injera* baking conditions. It also evacuates the smoke from the cook, and protects her from burns. These factors have led to the phenomenal success of this improved stove.

An adapted Mirte is now being produced for commercial *injera* bakers, with market assistance from another DFID regional commercial/institutional stoves programme. Savings are on the same scale as the household version, but the stove is more robust and designed for conditions in which cooks bake more than 300 *injeras* a day, and traditionally consume over 30kg of woody biomass per day. Over 500 of these stoves have been sold for an average price of US$65 since in April 1998.

The Mirte has become another African 'success story'. It demonstrates, as with the Lakech in Ethiopia and the Kenya Ceramic Jiko (KCJ) in Kenya, that energy conservation can pay and can be sustainable under urban poverty conditions if the right rules are followed.

The KCJ was developed with donor support in the early 1980s and over 2 million have since been sold without government or donor support at a competitive price of less than $5. It has provided work for hundreds of producers and vendors and has been successfully marketed in Tanzania, Malawi, Rwanda and Uganda. It, and the Lakech improved charcoal stove, have saved tens of thousands of tons of charcoal.

All these successful products have involved a rigorous attention to the marketplace, strong support for small-scale artisans and traditional markets, judicious use of small-scale credit, training and promotion, and an emphasis on a simple, replicable technological approach.

These success stories demonstrate that selling energy conservation in a poverty situation can be commercially viable and sustainable, and that multiple environmental, social and economic objectives can be achieved if the approach is right. ■

Mike Bess works for Energy for Sustainable Development (ESD) Ltd in England which has worked with a dedicated Ethiopian team on the Ethiopian Stove programme. ESD was awarded the Worldaware Award for its work on the Mirte in 1997.

the easy way

ESD

• into the future • into the future • into the future • into the future •

LIGHTING VIETNAM

More than 2,000 people have directly benefited from the installation of solar panels for domestic electricity in Vietnam, following a successful rural electrification project involving the Vietnam Women's Union (VWU).

The Solar Project in Support of Rural Women and Children has installed photovoltaic lighting systems in 130 homes and five community centres, as well as street lights in two village markets. These energy systems have helped to stimulate business and educational opportunities in five communities in the Mekong River Delta and Northern Vietnam.

Around 85 per cent of Vietnam's people live without electricity, and suffer health and safety hazards from the widespread use of kerosene lamps. It is estimated that the photovoltaic systems will offset over 39,000 kg of carbon monoxide released into the atmosphere each year by kerosene lamps. They have also provided light for using sewing machines after dark, contributing to an increasing in garment production, and the market streetlights provide an element of safety which has extended trading hours. Most of the installed systems provide electricity for about four hours of light and several hours of television each day.

Individual families financed their photovoltaic systems, costing $300, over a three-year period through a revolving loan fund managed by the VWU. Some have independently purchased black and white television sets. In the immediate region, a further 350 families have requested household photovoltaic systems, and the VWU hopes to expand its effort into a national programme of off-grid solar electrification.

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CADDET Renewable Energy

Asia's dream machine

One of the urgent challenges facing many Asian cities is that of pollution fuelled by ever-growing traffic. Now, a British high-tech company has designed a clean, electric, solar-powered people carrier that could help solve the problem. **Maya Pastakia** reports.

Taking a ride in a conventional autorickshaw is not for the faint-hearted. Their ancient two-stroke Lambretta engines, which run on a mix of petrol and oil, belch out enormous amounts of smoke. That, combined with badly maintained engines means even more pollution. The solution according to Frazer-Nash lies in microchips and the sun. This former sports car manufacturing company is convinced that the future of transportation lies in non-polluting vehicles and a team of engineers and designers have been put together to prove the point by cleaning up the rickshaw. The new vehicle, named the Solar Baby, is their brainchild.

In 1994, the Frazer-Nash team came up with the prototype of a solar-battery vehicle as a modern replacement for the petrol-driven rickshaw. It cleverly saves on energy by doing away with a mechanical differential. Each wheel is powered by a separate motor placed on each corner behind the wheel. At the centre and base of the car is a box of electronics – the brain of the vehicle – which controls the power fed to each wheel.

When driving straight ahead power is fed equally to all four wheels but turning a corner produces a huge power saving. The electronic controller will notice that the outside wheels need more current than the inside wheels and will deliver equal torque at differential speeds automatically. This delivers a big saving in power consumption compared to the traditional mechanical differential gearbox.

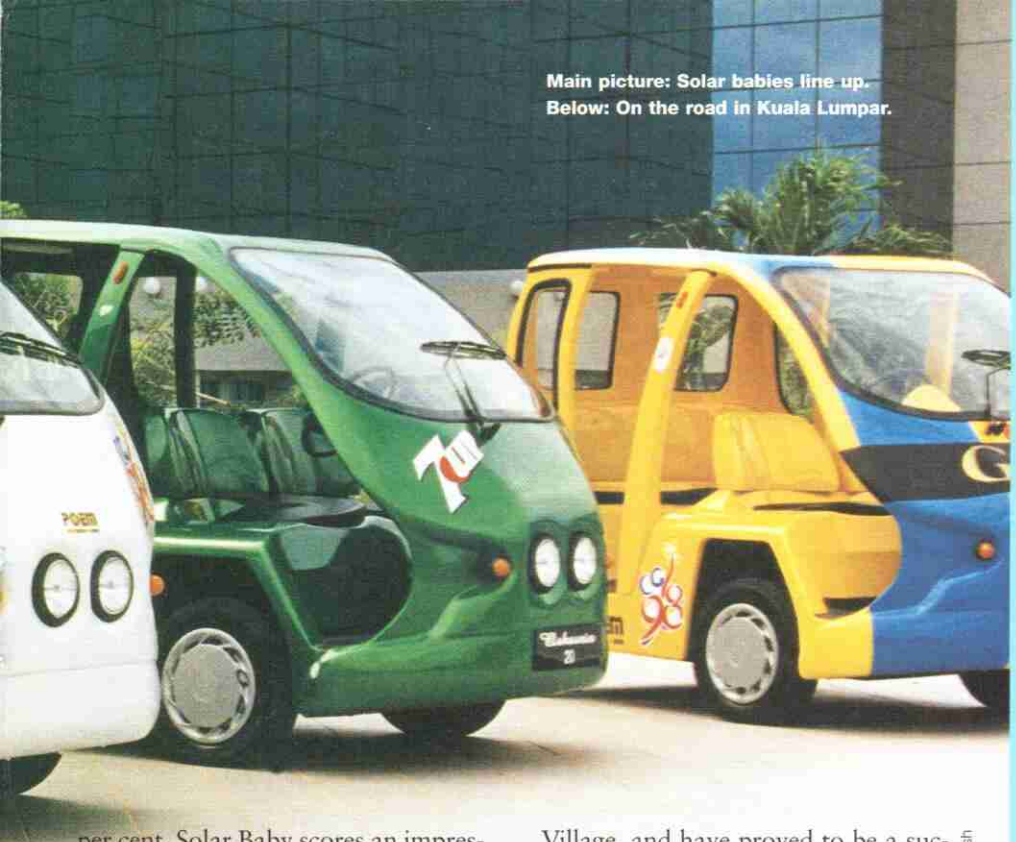
Energy is also saved in braking. With conventional vehicles, every time the driver brakes energy is wasted in heating the brakes. With Solar Baby, when the brake is applied the motors are switched to become dynamos, turning kinetic energy into electrical energy which charges the battery as the vehicle slows down.

As well as these energy-saving features, the designers have tapped into the sun's energy. The solar panelled roof converts radiation from the sun into electrical energy providing a trickle of power all day long to the battery pack, giving the rickshaw around 15 km extra free range each day.

If the battery does need recharging, it's just a matter of plugging it into a power socket. With rapid-recharging batteries installed, the procedure takes less than an hour and costs about 85 pence (US$1.40) A single charge can provide over 113 kms (70 miles), as well as the extra 15 kms free from the solar panel.

Driving is a breeze. The Solar Baby is very responsive and has simple controls: a forward and reverse gear and two pedals – one to go and one to brake. It has a top speed of 70 kph (45 mph). The stability of the vehicle is good because the majority of the weight of the vehicle is in the batteries underneath the floor, so the centre of gravity is low allowing for good handling.

One of the most outstanding features of the vehicle is its energy efficiency. While the efficiency of standard vehicles runs at around 20



Main picture: Solar babies line up.
Below: On the road in Kuala Lumpar.

Frazer-Nash

per cent, Solar Baby scores an impressive 95 per cent. Not only that, the running costs of the vehicle are only one-fifth of a petrol car and costs one penny per mile.

In addition to these benefits, there is very low maintenance. There is no need to regularly change the oil and filters and there are no cooling or exhaust systems as in standard cars. Even the brakes wear less because of the electronic braking.

Like the design, the manufacturing process is also efficient. While Frazer-Nash supplies the controllers, the bodywork and mechanics are made in Malaysia. Already, the Malaysian company POEM employs around 100 staff producing Solar Babies using very simple technology. The fibreglass body panels are fabricated using moulds which just takes one man and a brush, so that production can easily be scaled up.

The newly-designed vehicles were test-driven in Malaysia last year at the Commonwealth Games, ferrying athletes and delegates around the Games Village, and have proved to be a success. So impressed by the design is the Malaysian Government that it is backing production of Solar Babies.

For the moment, the battery-solar rickshaws are being introduced onto the road as five-seater taxis maintained by fleet operators. Soon the Solar Baby will be available to individual users. Larger battery-solar rickshaws and cars will follow.

With its chic look, sleek lines and energy-saving features, the Solar Baby looks like a winner. Many cities close to the equator have pollution problems and the market for these vehicles is huge. Frazer-Nash hopes to introduce the vehicle into Indonesia, Thailand and Singapore before long. The new-style rickshaw may soon be a common sight all over Asia. ■

For information on the Solar Baby and other electric vehicles, contact: Frazer-Nash Research Ltd, Mytchett Place, Mytchett, Surrey GU16 6DQ, UK.
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Email: marketing@frazer-nash.com

Frazer-Nash

QUEBEC WINDMILLS

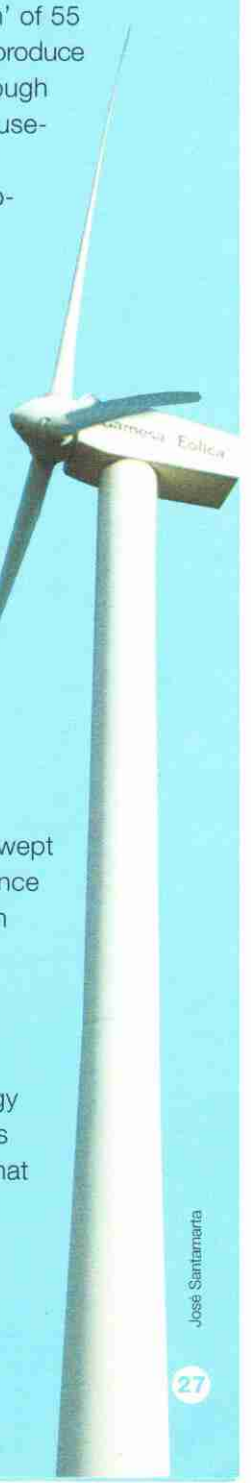
Quebec is a leading proponent of achieving the Kyoto target for Canada of 6 per cent reduction of greenhouse gas emissions below 1990 levels by the year 2012. It has a huge competitive advantage in the fact that it has so much hydroelectric power. It is now expanding that advantage by moving into windpower.

The first seven of 133 windmills started turning last October at the Le Nordais Wind Farm, Quebec. Being built at a cost of C$160 million, the windmills are perched on the blustery north coast of the Gaspe peninsula in the Gulf of St. Lawrence. The 'farm' of 55 metre windmills can produce 100 megawatts, enough to power 16,000 households, making it the largest such development in Canada.

"Only about four other projects in the world were built to this size," says Yvan Dupont, President of Axor International Inc. the privately owned Canadian member of the consortium building Le Nordais.

The largest such projects in Canada to date are in the windswept western prairie province of Alberta, which can generate 21 megawatts. With Quebec accounting for more than half of Canada's wind energy potential, Axor hopes to build more sites that can produce up to 3,000 megawatts of windpower.

Reuters



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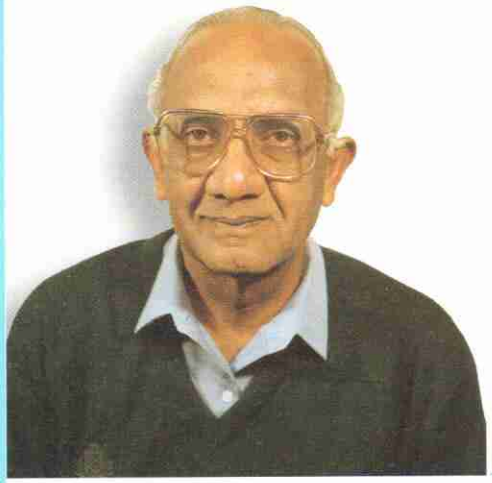

Professor Amulya Reddy is one of the world's leading authorities on sustainable energy. A professor at the Indian Institute of Science in Bangalore for over 20 years, he has acted as adviser in India and China and is now President of the International Energy Initiative. Set up in 1991, this aims "to promote the efficient production and use of energy for sustainable development". He talks to **Radhakrishna Rao**, in an exclusive interview for *People & the Planet.*

Learning from the village

Radhakrishna Rao: *Rural communities which depend on fuelwood have often been blamed for causing deforestation. But a recent survey points out that in India there has been a perceptible shift from fuelwood to other biofuels over the last 20 years. What has bought about this change in energy use?*

Professor Amulya Reddy: In the 1970s energy researchers propagated the view that poor rural communities indulge in massive deforestation to meet their energy needs. But a study carried out by the Centre for the Application of Science and Technology to Rural Areas (ASTRA) of the Indian Institute of Science (IISc) in Bangalore, conclusively proved that this view is false. Rural people meet their energy needs through the diligent collection of fallen twigs and branches. Without felling standing trees, they have been meeting their energy needs in a sustainable manner.

On the other hand, the rural poor have become the victims of deforestation caused mostly by commercial vested interests and urban fuelwood demands. It is because of this that the forests are thinning and receding at an alarming rate. As a result, rural folk have to walk longer and longer distances to collect fuelwood.

Meanwhile, fuelwood sourced from forests is marketed in the cities and towns of India in a big way. For example a study conducted by ASTRA in early 1980s revealed that as much as 20 per cent of the population in Bangalore, a booming city of 5 million plus people, is dependent on fuelwood for meeting its cooking energy requirements. What is surprising is that the fuelwood is brought into the city from distances of up to 600 kms. This not only causes massive deforestation, it also leads to the consumption of large amounts of diesel fuel used in lorries and trucks.

RR: *Do you think that increasing use of solar cookers can ease pressure on energy sources whose unsustainable use is being blamed for ecological ills?*

AR: Solar cookers and improved wood stoves have made only a marginal difference thus far in India. In the first place these devices are costly and unaffordable to a large segment of the rural community in India. Rural communities are accustomed to meeting their energy needs without monetary expenditure. Secondly, the technologies are still in the process of evolution.

More importantly, these non-conventional energy devices are not always suited to local needs. For instance, *jowar roti* (an Indian leafy bread made out of maize flour) accounts for a lion's share of cooked food in some parts of rural India, but it cannot be cooked using a solar cooker.

RR: *The institutions to support energy programmes are often quite indifferent to the social diversity and economic disparity common in India. What is the best way to overcome these shortcomings?*

AR: Any energy programme should clearly focus on making energy accessible – economically and efficiently – to all households in a region or country. The kind of energy source should be left to the discretion of the community.

For instance, a rural area with sufficient cattle and institutions capable of supporting a community-oriented energy programme could easily go in for community biogas. Similarly, villages rich in agricultural residues and wastes could use biomass gasifiers. Other areas lacking in these resources could perhaps opt for liquid petroleum gas (LPG) as has happened in many parts of Latin America.

Energy users should be at the centre stage of the entire energy planning strategy. Consumers should actively participate in the formulation of energy policies and in their implementation.

RR: *Both in India and China, for different reasons, the national biogas programmes have lost much of their steam. What future do you see for such programmes?*

AR: You are quite right to highlight the differences in these two countries. Right from the start the Indian biogas programme emphasised family-size plants, which were costly. Community-based plants never received the attention they deserved. Because the family-based individual biogas plants were not cost effective without heavy subsidies, the Indian biogas programme lost much of its steam.

In distinct contrast, the Chinese biogas programme was basically designed to meet the fertiliser needs of the agricultural sector. However with chemical fertilisers becoming cheap enough to be afforded by rural farmers, the biogas programme in China lost much of its relevance.

Perhaps other countries keen on popularising biogas could learn from the Chinese and Indian experiences. With a proper institutional framework and efficient management, countries could harness biogas to meet their rural energy needs.

RR: *India is a land of contrasts. Age-old bullock carts harmoniously coexist with nuclear power plants. What is the relevance of such a scenario to the ending of energy crisis in the country?*

AR: We have got to make use of both modern and improved traditional devices in an ecologically sustainable manner. Even age-old devices can be modernised and made cost effective. The eco-friend-

ly and economically viable bullock cart can serve the rural communities remarkably well. It is now being used to carry fertiliser and seeds from homes to farms and to bring back crops and fodder over unprepared cross-country terrains. Farmers also use bullock carts to carry their farm products to market. Such carts can play a role in meeting transportation needs.

Similarly, if nuclear power plants could meet economic criteria, stringent safety standards, reliable waste disposal requirements and security of fissile material from terrorists and military establishments, while winning social acceptance, they can contribute to the central power grid.

Developing countries have a historic opportunity to promote measures that would ultimately allow them to bypass the increasingly unsustainable patterns of the industrial countries.

RR: *Do you think that advances in developing photovoltaic devices for the satellite missions could be harnessed to boost the solar energy programme?*

AR: In fact, the drive to develop solar cells came first from the energy needs of satellites. Technological advances are now leading to a progressive decline in the cost of solar-powered devices. No wonder that solar power is a growing energy source in the world.

RR: *What role do you foresee for the small hydel schemes?*

AR: Connecting rural areas to a central power grid is an expensive proposition on account of the low demands and high transmission losses. In this context, India should definitely exploit the technology of small hydel projects to meet part of its rural energy needs, particularly because the country is rich in streams and small rivers.

A network of mini hydel power plants can deliver energy equivalent to a big hydel project without imposing a strain on ecological systems.

The Indian state of Kerala is planning to build small hydel power plants with the help of Chinese expertise. Countries which are particularly rich in hydel resources can implement such projects without inundation of forest resources or human displacement.

RR: *Nearly three-quarters of India's population which lives in rural areas receives less than a quarter of the total commercial energy consumed in the country. What makes for such a glaring disparity?*

AR: The reason is quite simple. It is easier and more economical to cater to urban consumers for whom the demand is higher and transmission losses are lower.

Because a majority of Indian villages do not have industrial units and other utilities consuming commercial power on a large scale, the disparity is partly in the nature of things. Of course, in the 'green revolution states' of Punjab and Haryana, agro-industries and mechanised agriculture consume a large amount of power. But in the rest of the country rural demands are lower.

RR: *Do you agree that biomass energy potentials in India remain significantly under used?*

AR: Because agriculture constitutes the backbone of the Indian economy, an enormous volume of agricultural residues is generated in the rural areas of India. There are also significant amounts of livestock wastes. Finally, many parts of the country are rich in woody biomass. Thus, the biomass energy potential is huge. But, the utilisation is poor because of constraints.

The constraints on biomass energy use could perhaps be overcome by launching pilot projects and making use of the experience to replicate projects. Human resources, effective management and appropriate technological options need to be harnessed while launching biomass-based energy projects. Above all, local conditions needs to be studied in depth at the outset.

RR: *Looking ahead, what future do you envisage for meeting the world's energy needs?*

AR: The world is meeting its energy needs. The big catch is whether the world's energy needs can be met in an environmentally sustainable fashion.

Energy can become an instrument for sustainable development. The point is that while the future may be difficult, continuation of the present trends cannot be sustained.

Unfortunately, the environmental advantages of newer and cleaner options are not rewarded in the market place. By correcting this distortion, we can move towards "a brighter and sustainable energy future".

But the rider is that the energy consumption of every section of the society should be met in an environmentally sustainable manner. Within an appropriate framework, public and private sector energy companies, governments and civil society can all contribute synergistically to meet the goals of sustainable development in the years ahead. ■

Radhakrishna Rao is a freelance journalist based in Bangalore.

NILE TURBINES

A turbine powered by the current in the River Nile has successfully replaced diesel-power pumps to supply drinking water to 5,000 displaced people in Juba, the major city in southern Sudan.

The Garman water current turbine floats on a pontoon in the river with the rotor completely submerged, moored to a post on one bank. Output from the pump flows through a 750m long pipeline to a tank 10m above the mean river level, holding 45,000 litres. From this tank, the water passes through a sand filter and from there into a smaller holding tank, feeding a pipe and tap system. At the lowest river level, the turbine delivers 2 litres/second to the filtration tank.

A French NGO, Action Contre la Faim (ACF), has been working since 1985 in Juba, which is still affected by the civil war, and the provision of safe drinking is a major part of its work. Originally, diesel-powered pumps were used, but the supply of diesel fuel was a continual problem. The original turbine has been running reliably for over two years. Recently, a second machine was added, in series, so that water can also be pumped to another tank higher up the hill.

A persistent problem has been the large quantities of water hyacinth which collect around the pontoon, eventually stopping the rotor. This problem has been reduced by moving the turbine slightly out of the main current. Major advantages of the system are the freedom from recurrent expenditure on fuel, and the supply of cleaner water because the inlet to the pump is in the mainstream of the river.

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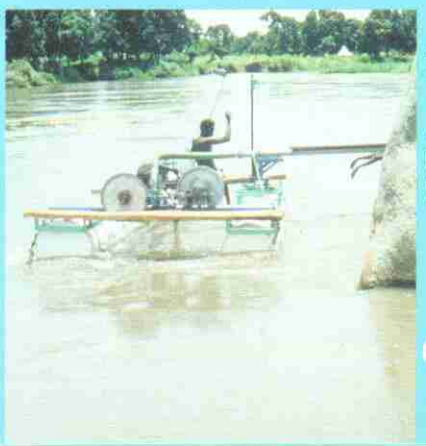


CADDET Renewable Energy

Last Word

Made to measure

Emerging countries will lead the way in small-scale sustainable electricity, says **Walt Patterson**.

Sustainable development requires sustainable energy. And sustainable energy will have to include sustainable electricity. As yet, we do not know what sustainable electricity looks like. But we have a pretty clear idea of what unsustainable electricity looks like. It looks like the traditional form of electricity that has spread over much of the planet through most of the past century.

The traditional electricity system is shaped by the economies of scale associated with water turbines and steam turbines. Large remote central stations based on these machines generate electricity in the form of synchronised alternating current, and deliver it to users over a network including long high-voltage transmission lines. This technical configuration has been spectacularly successful, so much so that most people in OECD countries take electricity completely for granted.

But traditional electricity systems have failed to reach more than two billion people, one-third of humanity. Moreover, the three most important traditional generating technologies – hydroelectric dams, coal-fired stations and nuclear stations – now face severe challenge, not only for their environmental impacts but also for their daunting capital cost.

Gas turbines

Traditional electricity systems are franchised monopolies. Traditional planners can order enormous plants, costing billions of dollars, taking six years or more to complete and at least another twenty years to pay off, because captive customers pay all the costs and bear all the risks. However, as electricity systems are freed from government control, shareholders and bankers have to share the risk; and long-term investments in traditional generating technologies become seriously risky.

At the same time, new generating options are emerging, more attractive both financially and environmentally. First comes the gas turbine, fuelled by cheap and abundant natural gas. Wherever natural gas is available, gas-turbine generation is now the option of choice.

Gas-turbine generation is economic at a smaller scale. It exhibits economies of series manufacture, with a rapid learning curve. It is modular, expanding capacity by adding more modules. It can be ordered, built and brought into service in less than three years. It is easier to site, cleaner and more convenient than the traditional technologies. It can therefore be located close to or indeed on the premises of electricity users.

The rise of gas-turbine generation is changing the technical configuration of electricity systems, from centralised towards decentralised, with more and smaller generators closer to users. Other innovative generating technologies with similar attributes are reinforcing this new trend e.g. mini- and micro-turbines, fuel cells, and a portfolio of renewable energy technologies including micro-hydro, wind, biomass and photovoltaics.

The traditional synchronised AC system demands large-scale centralised dispatching and control; power electronics, however, now allows systems to be much less tightly integrated and more flexible. The capabilities of new data-handling and system management technologies are likewise burgeoning.

Local systems

If communities, companies and other local users generate their own electricity close to where they use it, they will want to make sure it is used as effectively as possible, with high-performance buildings, lights, motors, electronics and so on. They will think in terms of the whole local system, not just the 'energy source'. They will want to optimise the whole system to deliver the services they want – comfort, illumination, motive power, information – not just the electricity. Optimising the whole local system thus makes sense both financially and environmentally.

The implications are profound. Much of this issue of *People & the Planet* has focused on local systems where people are still awaiting the benefits of electricity. Where the traditional large-scale centralised model faces insuperable obstacles, only local systems have any hope of delivering electricity services. The remarkable fact, however, is that even in the rich countries of the OECD, the shape of electricity is now evolving in the same direction, away from the traditional model towards a much looser network of local systems.

By a powerful irony, where people do not now have traditional electricity, they are also free of its technological and institutional inertia. They will be able to establish the innovative model much faster. As we enter the new millennium, today's emerging countries will lead the way towards sustainable electricity. ■

Walt Patterson, Senior Research Fellow in the Energy and Environmental Programme of the Royal Institute of International Affairs, London, is the author of *Transforming Electricity*, Earthscan, 1999 (see review on p34).

Gadfly by Norman Myers

200 years on...

We have just had the 200th anniversary of Malthus' famous statement. Let us commemorate it here by considering how much, or rather how little, some of us know about population.

Although population issues are likely to dominate their futures, many American students seem blissfully unaware of how many people they will have to share the world with. In 1995 Professor John Dunning of Purdue University in the United States – a leading academic institution – questioned 600-plus undergraduates on some basic facts and figures. He asked how many people there are on Earth, how many additional people are added each year, and how many people there are in the United States.

Answers to the first question ranged from 5 million to 9 quadrillion, with a mean of 15.2 trillion, whereas the correct answer was 5.7 billion. Even after deleting 35 responses greater than 1 trillion, the adjusted mean was still 31 billion. If we consider a roughly correct answer to be somewhere between 5 billion and 6 billion, then only one student in three was anywhere near correct.

Answers to the second question ranged from 2000 to 27.5 trillion, with a mean of 47 billion, the correct answer being about 95 million. After deleting 49 responses of more than 1 billion, the remaining 562 averaged 98 million, or almost correct. If an estimate of 90-100 million was considered correct, then only one student in fourteen got it right.

As for the population of the United States, the mean of responses was 6.8 trillion, the correct answer being 271 million. Eliminating 409 outliers of more than 5 billion yielded an adjusted mean of 596 million. If "correct" is taken to be between 250 million and 300 million, then about one student in four was on target – meaning that most students possessed less knowledge and understanding about their own country's population than about the world's population.

Many students had no concept of how large a billion, let alone a trillion, is. Dunning told them that a typical U.S. football field has some 286 million blades of grass, so four football fields contain at least one billion blades. Because it is hard to visualise the density of grass, he drew a square measuring two centimetres on each side, thus equalling the size of a patch of grass with the same number of grass blades as a classroom with 100 students.

One could suppose that many students in Britain might fare better than their American counterparts. But that could be questionable, given the 'awareness' of some of their teachers. A couple of years ago I was asked to write an article on the 'basics' of population in this country. The article went off to a referee, reportedly a population expert at one of our foremost universities. In his critique, the referee confused the country's population growth rate with its fertility rate; he had no idea of population momentum, supposing that establishment of the two-child family must result in an immediate halt to growth in numbers; and he viewed population issues within a demographic vacuum, dismissing as 'irrelevant' the environmental repercussions of 60 million people in a crowded little island.

Finally, let us ask if parents are sufficiently aware of the consequences for society when they have a third child. The 'spillovers' include the costs of housing, schooling and health facilities, the costs of food, the costs of pollution from fossil fuels, and so lengthily forth. Many of these are covered by parents through prices and taxes, but not all by a long way. How large can these costs be? Two innovative economists at Yale University have taken a crack at it, looking at ways in which above-two-children families can affect economic wellbeing overall. They have examined, for instance, the diminishing returns to society when conventional factors such as stocks of capital and land are divided up among increasing numbers of descendants. Their calculations show that the net costs to society per additional person range from $2500 in the poorest countries to $100,000 in affluent countries. This means that Britain's annual increment of 120,000 people will eventually impose costs of £7.3 billion on the rest of us.

This lack of understanding about population issues reminds me of those people who urge endless population growth by citing the verse from Genesis, "Go forth and multiply." But this was an injunction issued when the world's population was just two. ■

Dr Norman Myers is a Fellow of Green College, Oxford, and a Contributing Editor of *People & the Planet*.

● The full text of the Rev. Thomas Malthus' original *Essay on the Principle of Population*, published in 1798, is available in paperback from Oxford University Press, *World's Classic Series*, 1993, at £6.94.

Cairo+5 conference report

Show me the m

Delegates to the Hague Forum, the kick-off event for the much heralded five-year review of the Cairo Programme of Action on population and development, were stunned during the opening day by the announcement that Bill Gates would donate $2.2 billion to a family foundation that supports population and health initiatives around the world.

This extraordinary gift, made in Microsoft stock, brought the total endowment of the William H. Gates Foundation to $4.2 billion, making it perhaps the largest private foundation in the world concerned with social issues.

This largess came at the right time. Though progress has been made since Cairo in introducing reproductive health services into basic health care packages, upgrading family planning services, improving the status of women, and making information and services available for adolescents, the funding shortfall has seriously hindered work in most developing countries.

Delegates were told that the developed world's contribution is less than 40 per cent of the total called for, while developing countries are contributing about 70 per cent of the target set at Cairo.

Forward look

The Forum, held at The Hague, Netherlands from 8-12 February, was attended by representatives from 170 countries and 160 NGOs, including parliamentarians and youth organisations.

Over the course of the week over 200 speakers took the floor in the plenary session. In all, over 100 Ministers of State attended the Forum.

For the organiser of the Forum, the United Nations Population Fund (UNFPA), it was a big success, a chance for governments and NGOs alike to renew their commitment and compare notes.

This was especially valuable at the fringe events, such as the Face to Face sessions with personal testimonies from activists in the field, open discussions with panels of experts and the Cairo+5 Film and Video Festival which brought so many 'real people' into the vast, impersonal halls of the National Congress Centre.

Though there had been some fear that anti-ICPD forces, mostly right-wing fundamentalist religious organisations and so-called 'right-to-life' groups would try to sabotage the Forum, the Fund was able to steer clear of attempts to "re-open the Cairo agenda."

In the main committee, and related meetings, the Forum managed to craft a forward looking report that called for more progress in four main areas: creating an 'enabling environment' that would help everyone push ahead with the ICPD Programme of Action, stepping up work on gender equality and the empowerment of women as a foundation for the whole programme; strengthening partnerships, which the Forum itself helped to do; and mobilising money to pay for the Cairo agenda.

This last priority is one that was returned to again and again by speakers in the NGO and Government Forums and will hopefully be taken up seriously in the General Assembly in June. Mrs Eveline Herfkens, the Deputy Minister for Development Co-operation of the Netherlands, which has dedicated 4 per cent of overseas aid to population and reproductive health matters, was outspoken about the challenges that had to be met.

These include the need to guarantee good nutrition and healthy pregnancies; provide education for both boys and girls; promote safe motherhood; combat sexually-transmitted diseases; provide young people with the information and means to control their fertility; and focus attention on the growing needs of refugees and internally displaced persons, who now number some 30 million worldwide.

But how is this to be done when the main donor countries are over $2 billion behind their rather modest goal of providing $5.7 billion for population and development initiatives by the year 2000? In fact, of all the donor countries, only the Netherlands and the Nordic countries have come close to or exceeded their pledges in Cairo. The financial commitments made at Cairo have not materialised. It was time, Mrs. Herfkens concluded, for everyone to "put their money where their mouth is."

It was a question also addressed by Hillary Clinton in a rousing speech which won a standing ovation. "When nearly 600,000 women around the world still die every year – that is one every minute – this is no time to cut back on our commitments to family planning" she said. She reaffirmed her government's commitment to making abortion "safe, legal and rare" and announced that the President had proposed a $25 million voluntary contribution to UNFPA.

"And I hope that our Congress will support that request," she said. "The restoration of US funding would send a strong signal that the United States continues to support the ICPD Programme of Action."

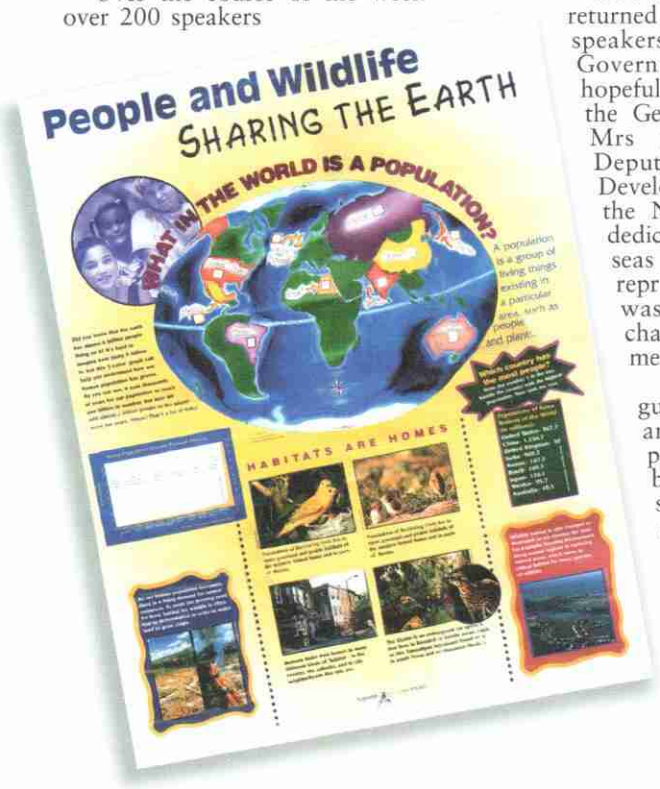
Health crisis

Another encouraging (though also very sad) aspect of the meeting was the presence on one platform of several Agency heads, all with a common message: there is a crisis of unsafe motherhood and of sexually transmitted disease, including HIV/AIDS, which is affecting young girls and women in particular.

Gro Harlem Brundtland of WHO, Carol Bellamy of UNICEF and Peter Piot of the joint UN programme on HIV/AIDS, joined Nafis Sadik of UNFPA in spelling out the scale of the problem.

According to Peter Piot "There is growing evidence that HIV is the single greatest threat to national welfare and development in a range of countries. In the nine most affected countries – all in Africa – where at least a tenth of the adult population has HIV, a child born in 2000-2005 can expect to survive only to the age of 43 instead of 60 as would have been expected in the absence of AIDS."

Zimbabwe, he said, expects that AIDS will consume 60 per cent of the health budget by 2005, with disastrous effects on other aspects of development including the literacy rates of children from AIDS-stricken households because families can no longer afford school fees.



Left : Poster for Audubon's Population and Habitat Campaign.

honey

The young are increasingly vulnerable, he said. UNAIDS has found that more than half of all new infections are now occurring among the under-25s. And girls are disproportionately affected. A recent study in one area of Kenya showed that one in four girls aged 15-19 were HIV-positive, compared to one in 25 boys in the same age group.

Meanwhile Dr Brundtland castigated as "inexcusable" the fact that several hundred thousand women die each year in childbirth. There had been little sign of progress, she said, when in parts of Africa one woman in every 16 risks death when they get pregnant.

New issues

The conference did raise some new issues that had little exposure in Cairo, some of them positive. There has, for example, been progress in highlighting the health problems associated with female circumcision. According to new findings by the Population Council, research suggests that young girls today are 10 per cent less likely to undergo the procedure than their mothers. There is also evidence about the growing usefulness of the 'morning after' pill as a method of contraception and of the female condom. But Dr Fred Sai, who chaired one of the Main Committee sessions on reproductive health, expressed concern that more was not being done to improve contraceptive methods.

There was also disappointment among some NGOs that the crucial link between population and the environment seemed to have disappeared from the Hague Forum Agenda. "We may at the world level be behind the world's women in seeing these linkages" said Peggy Curlin, Director of the Centre for Development and Population Activities (CEDPA) at a caucus meeting to discuss the issue.

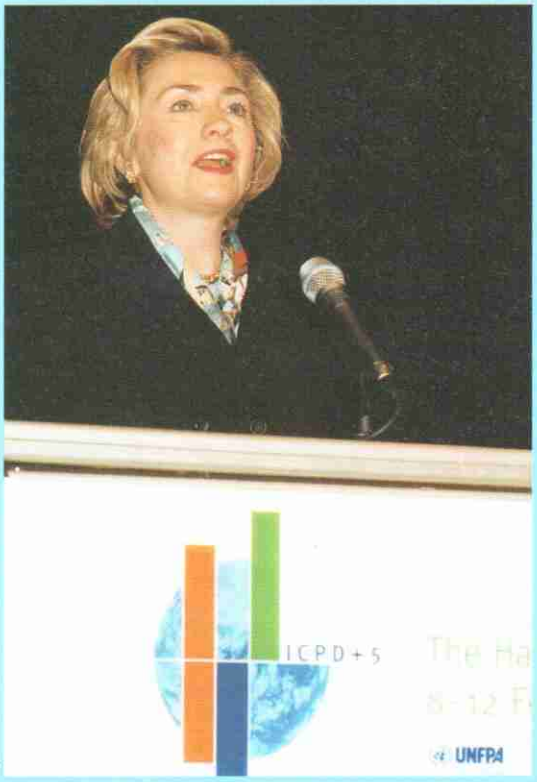
She instanced a project in Mexico where young people had developed a sexual and reproductive health project into an environmental campaign to save the local lake and another family planning programme for women in Nepal, who are now actively guarding a local forest to save the trees.

Pat Waak, Director of the Audubon Population and Habitat Campaign, said that environmental activists would make sure that the issue was explicit on the agenda when the Report of The Hague Forum is reviewed by the United Nations in New York. "The defining issue of our time is the relationship of people to the planet." ■

Don Hinrichsen and John Rowley

The formal process of review will culminate in the Special Session of the UN General Assembly from 30 June to 2 July 1999 in New York.

Change is coming



Arjen van de Merwe/WPF

Anita Anand led a team mainly of women journalists who produced a daily newspaper at The Hague Forum. Here are her thoughts on the event.

The Hague Forum was a small meeting, with about 1,500 people. It was held in one building and on two floors. There was only one entrance and security was firm but relaxed. No checking of bags, no photo IDs. There was little controversy, and a relatively quiet press. The highlight was the presence of Hillary Clinton (above).

Heard in the lounges, cafeteria and press room was that the Forum was boring, nothing was happening. For me, managing the publication of a daily *ICPD+5 Watch*, the lack of controversy and excitement was welcome. It allowed us to focus on the issues of reproductive health. Our small team of 10 people found plenty to write about and be busy for 14 hours a day.

Compared to Cairo, and maybe a comparison isn't fair, there was a relative ease with which country delegates, UN staff and NGOs mingled with each other. Mindful of each others contributions, assets, strengths and weaknesses, they moved in and out of each others sessions with ease. The blame, finger pointing and focus on who wasn't doing what was less than five years ago.

The background document prepared by UNFPA says that a major obstacle in the progress of the last five years has been a lack of understanding and outreach on the concept of reproductive health. Maybe five years is not enough for this?

Since 1994, NGOs (researchers, activists and health professionals) who played a major role in influencing UNFPA's decision to move from "population control" to "reproductive health" have been busy in devising ways to popularise the concept.

Focusing on advocacy to UN agencies, regional bodies, national and state governments and civil society, they have experimented with innovative field-based programmes involving men, women and mixed groups. There has been a flood of activities.

UNFPA and donor agencies have worked with governments to assist them in changing policies, supporting reproductive health research, organising seminars and meetings and training at all levels of the health care system.

In addition, NGOs and CBOs (community-based organisations) who have been doing innovative reproductive health work are being recognised and hailed as role models. The stacks of reports, booklets and case studies that were piled in the documentation section are proof of this.

At The Hague, NGOs organised sessions to meet with women and men who have been active in the last five years (and before).

There was a refreshing absence of the right to lifers and opponents of abortion and sex education, so by and large the Forum could get on with its business of reviewing the agenda of the last five years. The statement of the Holy See representative was a lot more moderate than at ICPD in Cairo but continued to deny women and young people rights over their reproduction and sexuality.

A lot was said about "political will and financial resources" being major obstacles to progress of the ICPD Programme of Action, and donor countries were urged to redouble their efforts to reach the $5.7 billion target for international assistance by the year 2000, as agreed in Cairo.

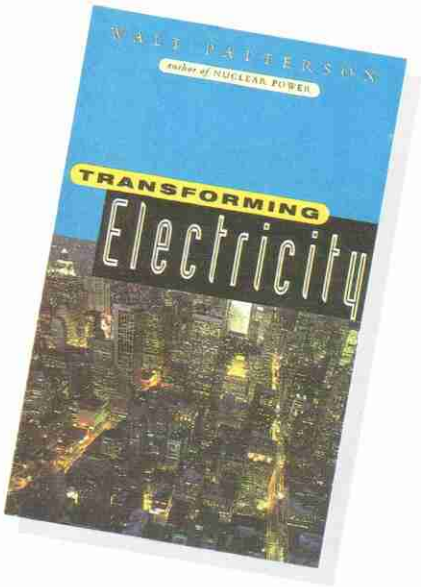
What's new about the discussion of reproductive health at The Hague Forum is that it is just beginning to be more widely understood and internalised. The words sex and sexuality are used in the context of population and development discussions much more than they used to be. And, that countries and people have a lot to learn from each other. ■

Anita Anand is Director of the Women's Feature Service in Delhi.

Books

ELECTRIC VISION

TRANSFORMING ELECTRICITY: THE COMING GENERATION OF CHANGE
Walt Patterson
Earthscan, London, 1999, £12.99 pb



The enthusiastic heralding of revolutions is part of the frenetic backdrop to modern technological change. Such clarion calls are nowhere more familiar than in the field of environment and sustainability, where they have become something of an occupational hazard. But this book – with its powerful and engaging imagery, its readable style, its panoramic scope and its relaxed authority – is a classic of the genre.

Walt Patterson is a respected veteran of the energy business. He secured his well-earned reputation many years ago with his definitive book on the politics and technology of nuclear power. With a physics background, a key role in the establishing of Friends of the Earth in the UK and a more recent career as a professional energy analyst at the Royal Institute of International Affairs, Patterson is as comfortable with the complexities of the world's electricity systems as he is with the diverse imperatives of modern environmentalism.

With plenty of well-drawn examples and succinct historical excursions, Patterson guides us through the whirlwind of technical and institutional change now sweeping the global electricity supply industry. Emerging technologies like combined cycle gas and wind turbines, solar and fuel cells, along with computerised control and new power electronics are coming together with trends towards privatisation, liberalisation, decentralisation and globalisation to mix a heady cocktail of implications for the electricity supply which so many of us take for granted.

Avoiding the sterile polemics of nuclear and renewable energy critics and advocates alike, Patterson offers a refreshing vision of how this newly invigorated industry may actually make some long-due progress on the daunting challenges of climate change, pollution and worldwide energy poverty. Yet, showing how old habits, assumptions and stabilities of the past century of evolution in electricity systems are now being swept away, he reveals the prospect of new inequities and insecurities as well as desperately needed solutions.

In this book, as in life, energy efficiency is the Cinderella of the story. It might have been nice to read more about the technologies and policies which are transforming the way we use electricity. Likewise, it is surprising amid the repeated allusions to new direct-current transmission and generating technologies to find the relative neglect of important developments like the advent of 'intelligent meters' and the potential future interactions between electricity and transport systems.

Nevertheless, Walt Patterson has achieved in this book an excellent introduction for the lay reader at the same time as presenting a stimulating tonic for the energy specialist. He has managed to condense a huge amount of important but indigestible material into an exciting and informative read. Just like his earlier work on nuclear power, it would be surprising if some of the key players in the electricity revolutions of the twenty-first century don't trace their interest back to this book. If that happens, the Environment owes Walt a doubly weighty debt.

Andy Stirling

Dr Andy Stirling is an environmentalist and fellow at SPRU (science and technology policy research) at the University of Sussex, England.

ELECTRIC READING

Among the vast literature on electricity and renewable energy the following titles are especially useful, *writes Walt Patterson.*

Energy for a Sustainable World, by Jose Goldemberg of Brazil, Thomas B. Johansson of Sweden, Amulya K. N. Reddy of India and Robert H. Williams of the US (Wiley Eastern 1998) was a sweeping, prescient and visionary overview of the emerging relationship between sustainability and energy, and a landmark in the global policy debate.

Long a deeply conservative influence on global energy policy, the World Energy Council at last emerged as an impressively forward-looking body with its report *Energy for Tomorrow's World* (Kogan Page, 1993). Its subsequent reports on *Renewable Energy Resources: Opportunities and Constraints 1990-2020* (WEC 1993) and *Global Energy Perspectives to 2050 and Beyond*, a joint study with the International Institute for Applied Systems Analysis (WEC/11ASA 1995), reinforced the World Energy Council's role in leading the global energy community.

Renewable Energy for Fuels and Electricity, by Thomas B. Johansson and others (Earthscan/Island Press, 1993), a 1160-page encyclopaedia prepared by many of the world's foremost experts at the request of the United Nations, instantly became the bible of renewable energy advocates everywhere and remains so.

Power Surge, by Christopher Flavin and Nicholas Lenssen of the Worldwatch Institute in Washington (Worldwatch /Earthscan, 1995) is a readable and entertaining survey of new developments in energy technology and policy.

Factor Four, by Ernst von Weizsaecker, Amory B. Lovins and L. Hunter Lovins (Earthscan, 1997) is an enthralling tour de force, demonstrating with a cornucopia of striking specific examples how we can double our global wealth while using only half as many resources. Generating and using electricity both figure prominently (see review in *People & the Planet* Vol 6/4).

ON THE NET

The Internet is an excellent way to keep track of fast-moving energy developments at very little cost. The sites listed in this brief selection include many links to other relevant sites.

Energy and Environmental Programme, Royal Institute of International Affairs: <www.riia.org/eep.html>

World Bank: <www.worldbank.org>

United Nations Development Programme: <www.undp.org>

United Nations Environment Programme: <www.unep.org>

World Energy Council: <www.wec.co.uk>

International Energy Agency: <www.iea.org>

Electric Power Research Institute: <www.epri.com>

Worldwatch Institute: <www.worldwatch.org>

Rocky Mountain Institute: <www.rmi.org>

Renewable Energy Policy Project: <www.repp.org>

Kim Naylor-Christian Aid/Still Pictures

Friends of the Earth International: <www.xs4all.nl/~foeint>

Greenpeace: <www.greenpeace.org>

Solstice: <www.solstice.crest.org>

Natural Resources Defence Council: <www.nrdc.org/sitings/links/linkener.html>

Open University Energy and Environmental Research Unit: <www-tec.open.ac.uk/eeru>

FT Energy: <www.ftenergy.com>

McGraw-Hill: <www.powermag.com>

Electricity Journal: <www.electricityonline.com/1library.html>

Films

COW POWER

Most of India's one million villages are connected to the country's national electricity grid but the supply is notoriously unreliable. Nowadays though, as Michelle Maillet's informative documentary shows, when the lights flicker off, many of India's rural population now have an independent power backup – and it runs on cow dung.

The 23-minute film, *Biogas*, visits the state of Gujerat, where many families and villages now have their own biogas plant. It shows how villagers collect all their waste organic material like animal dung, human waste and vegetable matter into an airtight concrete tank, where bacteria slowly digest it to produce a gas which is roughly 60 per cent methane and 40 per cent carbon dioxide. The gas is then piped to the house to be used directly for cooking and heating, or to run electricity generators.

Despite its origins, the gas is completely clean, odourless and atmospherically friendly – it keeps carbon dioxide emissions neutral and emits no sulphur. Cooking with clean-burning gas, rather than smoky wood, improves respiratory health and reduces the pressure on fuelwood. Even the sludge that comes out at the end makes an excellent fertiliser.

But biogas is taking off in many other parts of India. In towns and cities where waste is available in bulk, biogas production plants can operate on a much bigger scale. At the Pumjee Paper Mills in Poona, they have incorporated biogas into their production processes, to cut back on their energy bills and pollution. The factory's biogas plant uses wastes from the pulping process and provides 15 per cent of power requirements. Many Indian companies, among them chocolate manufacturers and distillers, are following suit. An added bonus is that the effluents used to make biogas are broken down in the process, making the resulting waste water easier to treat.

HANDS ON

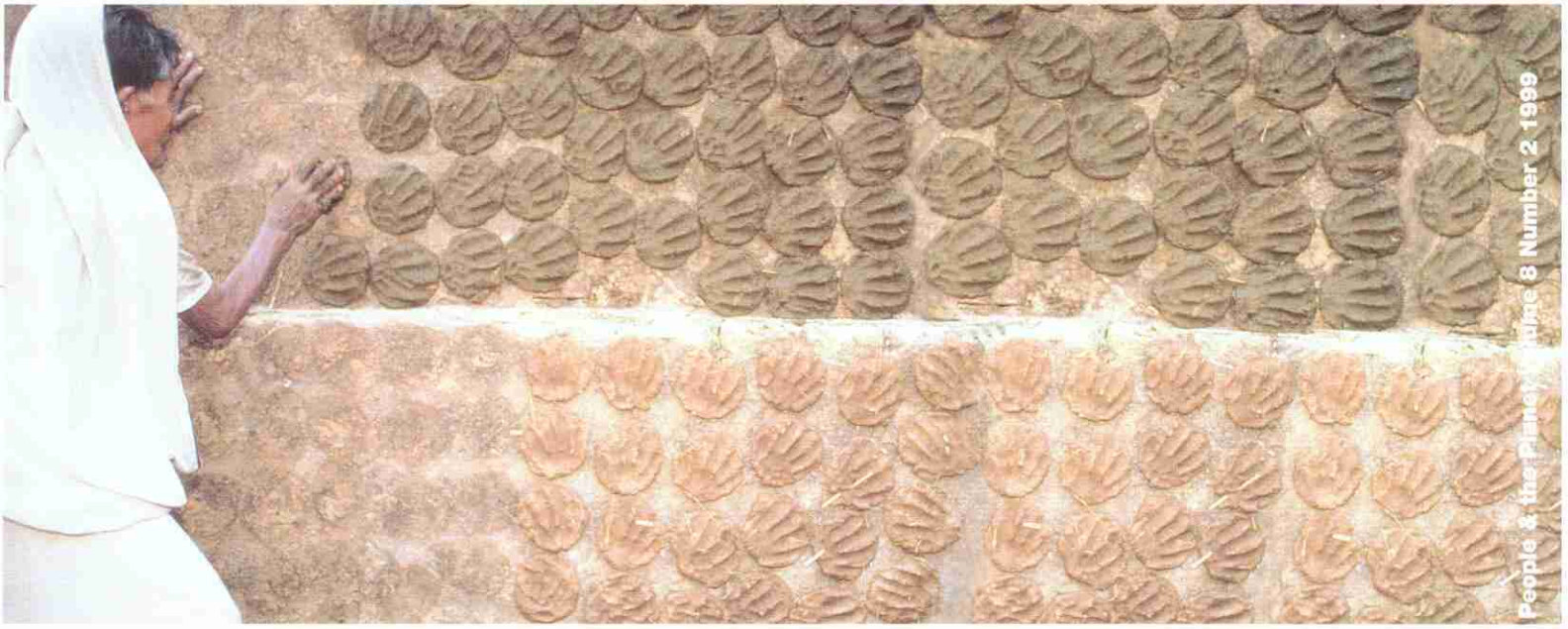
India has shown the world that muck makes power. Now the technology has spread to a number of developing and developed countries. *Who's Got The Power*, an *Earth Report 'Hands On'* special lasting 26 minutes, showcases a range of renewable energy technologies. It visits Northern Germany, where Dieter Prenzler fuels his farm and buildings with biogas generated from the bodily waste of 1,200 pigs, 4,000 chickens and his family. To this he also adds waste fats from the restaurants of Hamburg, and he gets paid for his trouble. His system produces sufficient gas to heat, light and power the farmhouse and outbuildings and if he's lucky he still sells the excess energy to the electricity company.

But the benefits of any low-tech renewable energy source are not just environmental. Reporting from Peru *Who's Got The Power* shows how local, clean energy generation can bring a huge range of social benefits to remote and poor areas. Ninety-six per cent of Peru's rural population are without electricity and are too remote to be connected to the national supply. In Cajamarca in the Andes, Intermediate Technology has set up a pilot project with the local farming co-operative to build a mini hydro-electric generating plant to serve the needs of the local community. These micro-hydro schemes are cheap to build and run.

With electricity a range of opportunities suddenly become possible; the local carpentry business can use power tools, the community can tune into developments in the outside world through television and radio and the co-operative has invested in a computer to help run its affairs. The brightly lit homes in Cajamarca are proving that micro-hydro provides the means to power Peru's remote communities.

Nick Rance

Who's Got The Power also features reports on wind power, solar power and energy efficiency and is part of TVE's series *Earth Report* which is broadcast on BBC World and national terrestrial channels. *Biogas* is production of Bernard Lang AG. Both programmes are available from TVE, Distribution Unit, Prince Albert Road, London NW1 4RZ, UK.
Tel: + 44 (0)171 586 5526,
Fax: + 44 (0)171 586 4866,
Email: tve-dist@tve.org.uk



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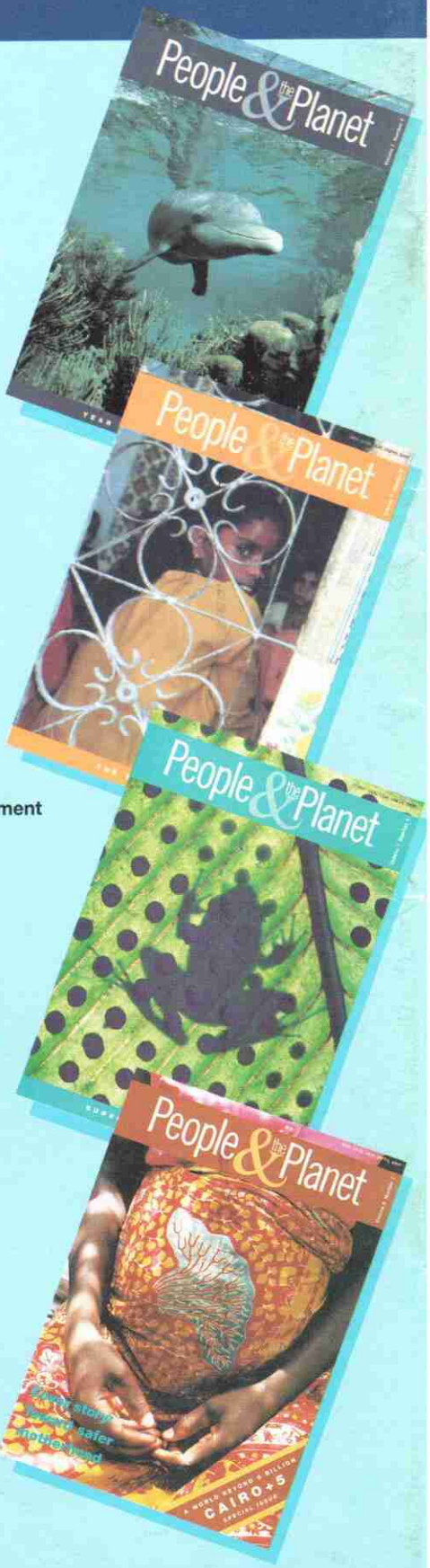

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